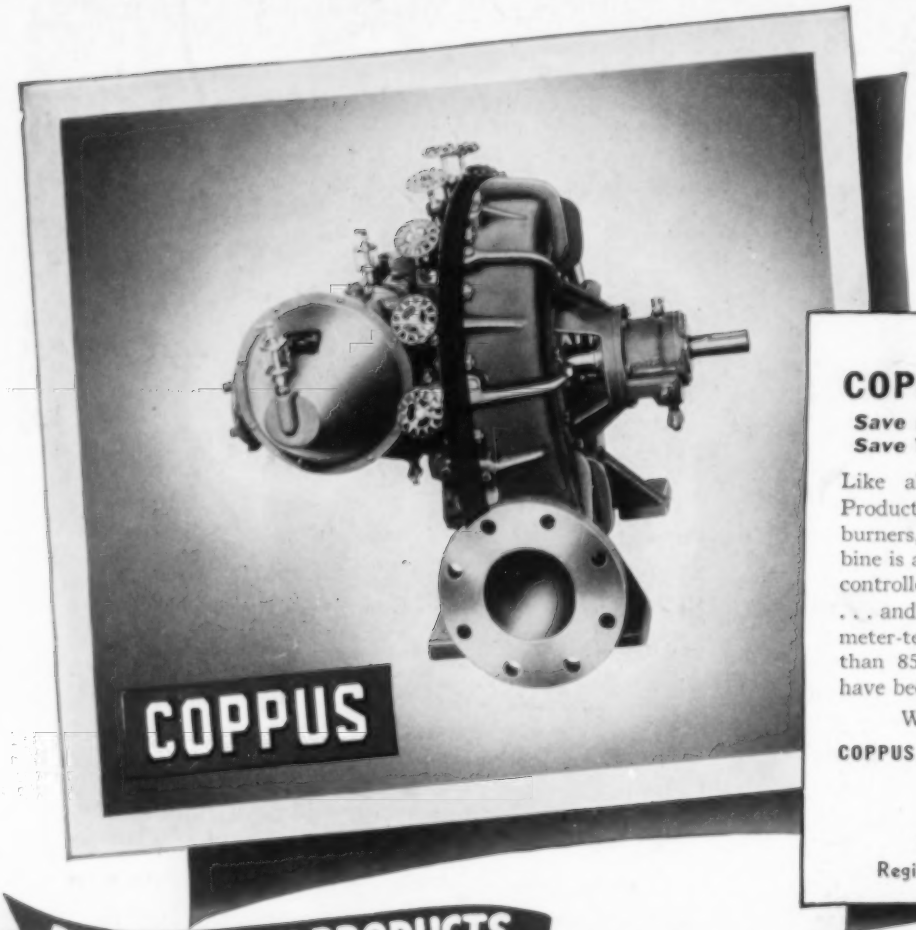
Compressed Air Magazine

JULY 1943

"--by the dawn's early light--"

VOLUME 48 • NUMBER 7

NEW YORK • LONDON



COPPUS TURBINES

Save Metal in Wartime — Will Save You Money in Peacetime

Like all Coppus "Blue Ribbon" Products (blowers, ventilators, gas burners, etc.), the Coppus steam turbine is a precision-made product . . . controlled by Johansson size blocks . . . and every turbine is dynamometer-tested before shipment. More than 85% of all orders since 1937 have been repeat orders.

Write for Bulletin 135-9

COPPUS ENGINEERING CORPORATION

357 Park Avenue,
Worcester, Mass.

Sales offices in Thomas Register; Products in Sweets Cat.

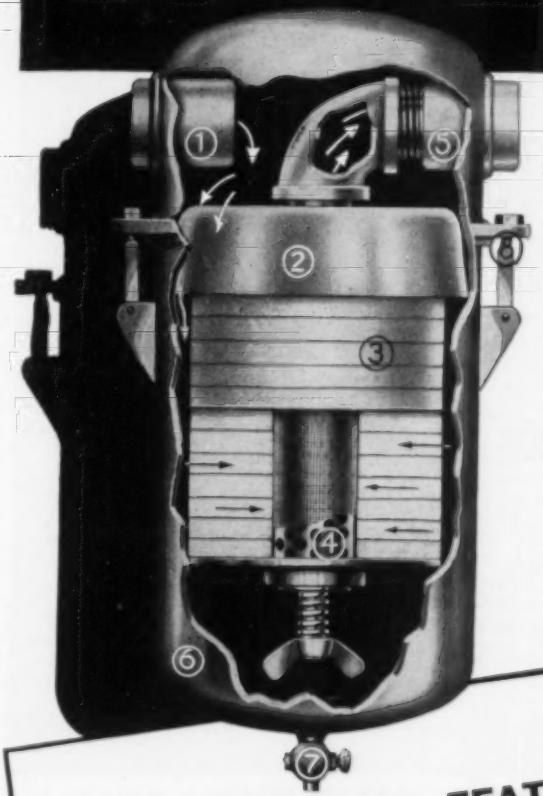
BLUE RIBBON PRODUCTS

DESIGNED FOR YOUR INDUSTRY...ENGINEERED FOR YOU

If a COPPUS "Horse Power" Steam Turbine can power your pump, blower, fan, stoker, dryer, mixer, etc. . . . then you'd waste money and metal buying an "Elephant Power" Turbine. COPPUS Blue Ribbon Turbines come in 6 frame sizes; matching size to job saves critical metal for war and money for yourself.

And the blue ribbon means workmanship that promises peak performance.

HAZARD of Oil and Moisture in Automatic Controls NOW ELIMINATED



New Filter Delivers Dry Air Only

Amazing results are being reported by users of Staynew's Model AAPHS Pipe Line Filter as a final stage in the protection of delicate pneumatic control instruments.

Typical comment is that of a large producer of electric and steam power who says, "We tried several well-known methods of moisture and oil elimination without satisfactory results. Your Model AAPHS was finally installed in the air line and since then we have had no trouble whatever with oil or moisture in our automatic controls."

NEW 44-PAGE CATALOG: Describes entire line, including filters for building ventilation, pipe lines, engine, and compressor intakes. Your copy is ready.

Representatives in Principal Cities

CONSTRUCTION FEATURES

(1) inlet; (2) baffle that distributes vapor-laden air to sides of container (6); (3) felt rings; (4) perforated liner; (5) outlet; (7) drain cock; (8) swing bolts for easy inspection (optional).

THICK FELT RINGS that remove every trace of oil or moisture.

SPECIFICATIONS

Model	Standard Pipe Size	Capacity
AAPH-02 AAPHS-02	¼"	5 CFM
AAPH-01 AAPHS-01	¼"	7 CFM
AAPH-0 AAPHS-0	½"	10 CFM
AAPH-1 AA-PHS1	¾"	20 CFM
AAPH-2 AAPHS-2	1"	30 CFM
AAPH-4 AAPHS-4	1½"	50 CFM
AAPH-5 AAPHS-5	2"	100 CFM

Letter S in code numbers indicates swing-bolt type which facilitates inspection.

Write for Bulletin "A"

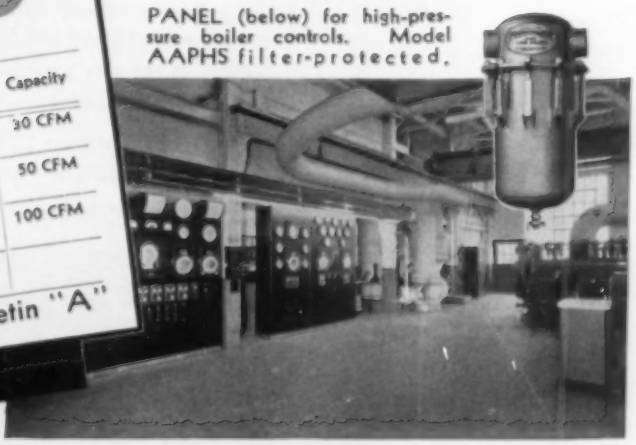
STAYNEW FILTER CORP.

7 CENTRE PARK, ROCHESTER, N. Y.

"Air Filter Headquarters"

PROTECTOMOTOR AIR FILTERS

PANEL (below) for high-pressure boiler controls. Model AAPHS filter-protected.



Eimco Model 21 Loader opening new stope.

Alert mine operators have been fighting on two fronts underground for some time. In the early stages of World War II Eimco Loaders were employed in ferrous and non-ferrous metal mines to speed development work, to bring in new ore bodies or enlarge existing ones—running tunnels, drifts and cross-cuts—advancing the first front in anticipation of the day when demand for war metals would be enormous.

Then came December 7, 1941, and mine operators everywhere gathered their strength, mobilized their Eimco Loaders and opened a "Second Front."

Time to put Eimco Loaders on the "Production Front"—more copper, lead, zinc, nickel, molybdenum, iron ore for guns, airplanes, tanks and ships. Today Eimco Loaders are loading millions of tons of ore annually—no time for elaborate methods—put Eimco Loaders in stopes, drifts and cross-cuts ON ORE! No time for hand methods, ore chutes and gates, so offset labor and material shortages by letting Eimco Loaders do the job of getting out the ORE!

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH, U.S.A.

NEW YORK	CHICAGO	EL PASO	SACRAMENTO
120 Broadway	111 W. Washington St.	Mills Bldg.	1217 7th St.

BUOYANCY FROM A *Cylinder*

In only 60 seconds this 7-man raft inflates itself from its own self-contained bottle of CO_2.

LAST word in life-saving equipment for our bombers, this seven-man raft can be inflated in one minute by turning the valve on the cylinder of CO_2 which is connected to the raft at all times. Supplying CO_2 for these cylinders is one interesting wartime use of compressors.

Whether compressing CO_2 for life rafts or compressing air for thousands of industrial uses, compressors everywhere are kept at maximum efficiency . . . lubricated with *Texaco*.

Texaco Alcaid, Algol or Ursa Oils keep compressors free from hard carbon deposits. Valves open wide and shut pressure-tight; rings stay free, ports and air lines clear.

So effective have Texaco lubricants proved in increasing output that they are definitely preferred in many other important fields, a few of which are listed in the panel.

A Texaco Lubrication Engineer will gladly cooperate in the selection of the most suitable lubricants for your equipment. Just phone the nearest of more than 2300 Texaco distributing points in the 48 States, or write:

The Texas Company, 135 East 42nd Street, New York, N. Y.

THEY PREFER TEXACO

★ More stationary Diesel horsepower in the U. S. is lubricated with Texaco than with any other brand.

★ More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.

★ More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.

★ More revenue airline miles in the U. S. are flown with Texaco than with any other brand.

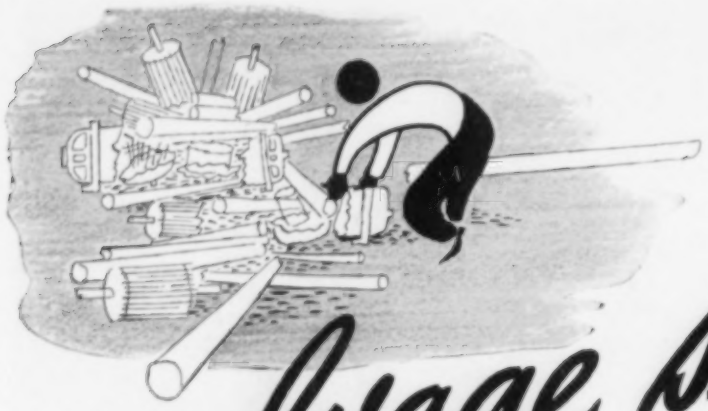
★ More buses, more bus lines and more bus-miles are lubricated and fueled with Texaco than with any other brand.

TEXACO

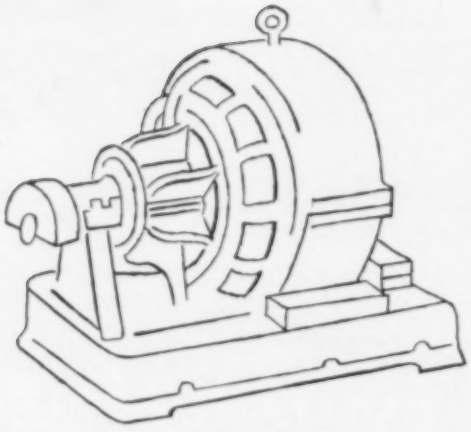
TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO STAR THEATRE EVERY SUNDAY NIGHT – CBS ★ HELP WIN THE WAR BY RETURNING EMPTY DRUMS PROMPTLY



salvage searched



to replace broken shovel motor-shaft in one day's time

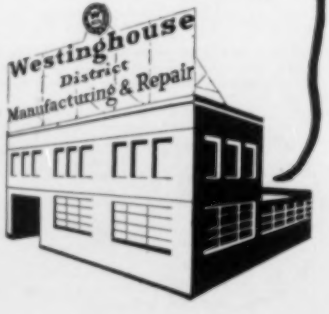
SHAFT ON 37 HP SHOVEL MOTOR SNAPPED AT 4:00 P.M. FRIDAY. MOTOR RECEIVED AT WESTINGHOUSE DISTRICT MANUFACTURING AND REPAIR PLANT 11:00 A.M. SATURDAY. STEEL FOR NEW SHAFT COULD NOT BE DELIVERED PROMPTLY. SEARCHED SALVAGE AND MACHINED LARGER MOTOR SHAFT TO CORRECT DIMENSIONS. MOTOR ASSEMBLED AND SHOVEL OPERATING AT 4:00 P.M. SUNDAY.

Westinghouse

DISTRICT MANUFACTURING AND REPAIR

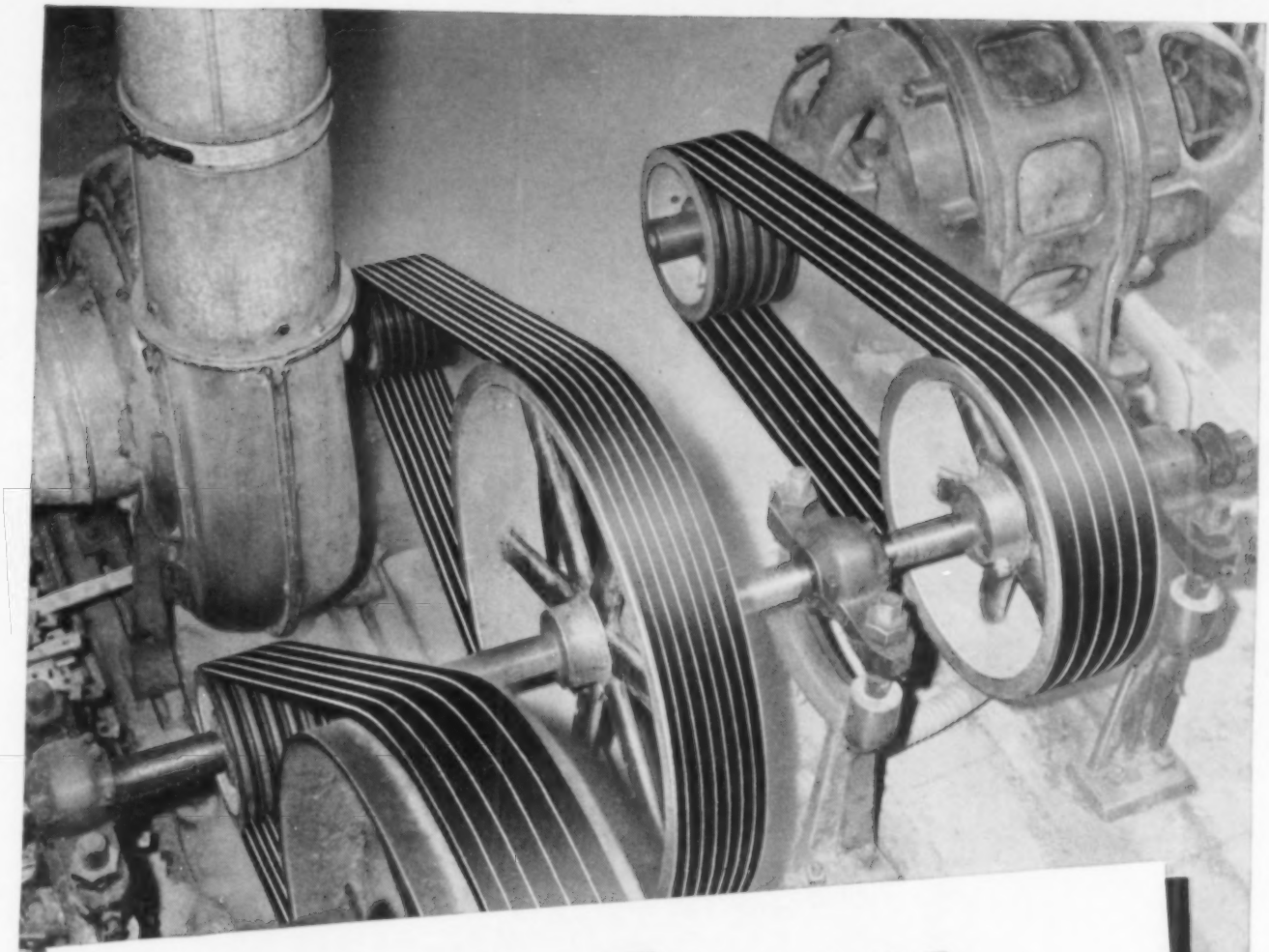
J-90467

IF **THE EQUIPMENT NEEDING REPAIR IS VITAL TO THE WAR EFFORT . . . PHONE THE NEAREST OFFICE OF WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY FOR**



EMERGENCY SERVICE

33 M & R PLANTS . . . ONE NEAR YOU!



BATTLE STATIONS—

Machines driven by Dayton V-Belts man the battle stations of the production line. And in over 100,000 war-vital plants tough, durable Daytons stand up under high speeds, peak loads and shock loads despite staggering work schedules, excessive temperature, dust and moisture conditions. Built-to-bend Daytons grip firmly and transmit smooth-flowing power for every kind of job from sun-up to sun-up around the calendar. For American industry at war Daytons are increasing output, cutting power losses, reducing maintenance, protecting machinery and conserving time, money and floor space.

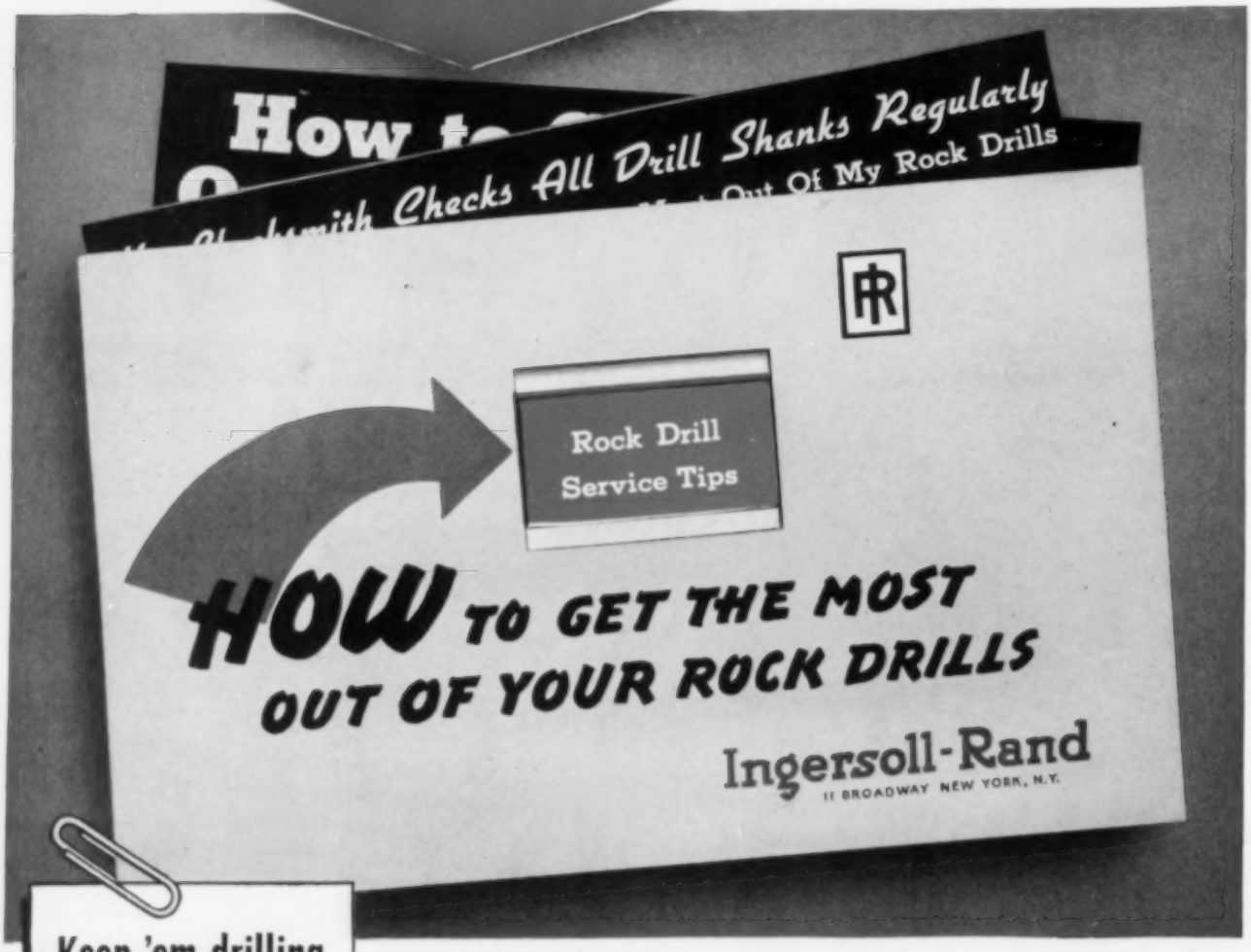
Near you is a Dayton distributor whose stock of V-Belts is supplemented by strategically located factory warehouses. Call on him for service or helpful suggestions regarding the conservation of V-Belts.

THE DAYTON RUBBER MFG. COMPANY
The World's Largest Manufacturer of V-Belts
DAYTON OHIO

DAYTON RUBBER EXPORT CORPORATION
38 Pearl Street New York, N. Y. U. S. A.

Dayton V Belts
LIFELINES OF POWER VITAL TO VICTORY

COMPLETE SET OF
ROCK DRILL SERVICE TIPS
NOW AVAILABLE IN HANDY FOLDER



Keep 'em drilling

Ask your supplier for an oil that meets I-R Specification 433 — the new rock drill lubricant developed by Ingersoll-Rand.

In 1939 and 1940 we devoted considerable advertising space to a series of rock drill service tips entitled "How to get the Most Out of Your Rock Drills." These have been reprinted time after time. Many thousands of reprints have been distributed to mining men, contractors and quarrymen in all parts of the country.

Today, the maintenance of rock drills is of even greater importance than it was in 1939. Therefore, in order that your men may be reminded of the importance of the proper care and handling of their machines, we have printed a 9th edition of these service tips and have enclosed them in a new, convenient folder.

A supply of these handy folders may be obtained for your men—or for bulletin boards, payroll envelopes, and lecture courses—by writing or phoning the nearest I-R service branch or the head office at 11 Broadway, New York City.

COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

5-318

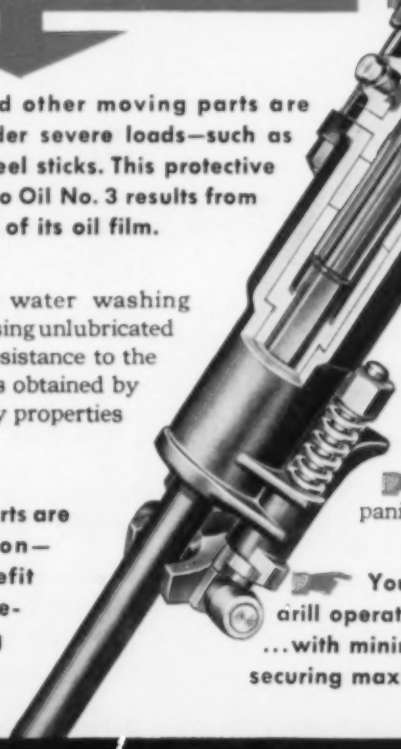
Ingersoll-Rand
11 BROADWAY, NEW YORK, N. Y.

HOW TO SOLVE OPERATING PROBLEMS WITH *Correct Lubrication*

New Type Rock Drill Oil "Fortified" to meet Severe Operating Conditions

GARGOYLE ALMO OIL NO. 3

is a High-Quality Mineral Oil Specially Compounded to give Operators these Benefits:



Rifle bar, nut and other moving parts are guarded from wear under severe loads—such as caused when the drill steel sticks. This protective feature in Gargoyle Almo Oil No. 3 results from the exceptional strength of its oil film.

Wear caused by water washing away the oil film and exposing unlubricated surfaces is minimized. Resistance to the washing action of water is obtained by strong adhesive and tacky properties in the oil.

All internal drill parts are guarded from corrosion—another important benefit provided by this oil's resistance to the washing effect of water.

Piston seal is maintained because cylinder walls are continuously oil-wet despite washing action of water.

Maximum drill speed is assured by the correct body of this oil.

Valve action stays free. Gummy products which stick valves are not formed when this oil is used.

No objectionable odor or eye-burning accompanies the use of this oil.

You get extra assurance of obtaining continuous drill operation . . . at maximum speed ...with minimum stalling—and thus securing maximum production.

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION

CALL IN SOCONY-VACUUM

GARGOYLE Lubricants

SOCONY-VACUUM OIL COMPANY, INC.— Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California

HERCULES
TAMPTITE
TAMPTITE
Speeds work – saves time
A Tamptite cartridge is easily, quickly inserted into the bore hole in the usual manner. No wasted man-hours slitting cartridges. No loose, spilled powder to worry about. Then—

TAMPTITE
Packs snugly
gives better breakage
You tamp a Tamptite cartridge in the usual manner. It packs evenly, snugly—leaves little air space—concentrates the charge for good breakage, faster mucking.

INCREASED TONNAGE, together with savings in valuable man-hours, can be gained by using your regular Hercules explosives in the new Tamptite* cartridges. Tamptite shells are convenient, easy to use. They eliminate the mess and trouble of slitting cartridges. They compress in the bore hole with a compactness that assures good breakage. And, the better breakage, of course, means easier, faster mucking. In fact, Tamptite speeds up your entire mining cycle. On your next order, specify Hercules in Tamptite cartridges.

HERCULES EXPLOSIVES

HERCULES POWDER COMPANY
INCORPORATED
932 KING STREET • WILMINGTON • DELAWARE

*Reg. U. S. Pat. Off. A-99

Keep Your Lubricants *Clean!*

Dirt and grit and similar abrasives which are allowed to creep into the lubricant to grind and damage your equipment, are Fifth Columnists.

They are often the causes of failures for which something else is unjustly blamed. Guard your vitally important excavator against such **preventable** operating interruptions. Keep it working for victory.

THESE SIMPLE PRECAUTIONS WILL INSURE CLEAN LUBRICANTS:

1. Be sure oil and grease comes to you clean.
2. Keep lubricants covered and stored neatly in a clean place.
3. Drain oil enclosures when hot so the draining oil carries off the sludge.
4. Keep funnels, plugs and oil spouts clean. Wipe off oil can covers before removing.
5. Keep empty containers that are to be refilled clean and tightly covered.
6. Clean enclosure covers before removing for inspection.
7. Clean outside of grease gun before using.
8. Clean fittings so that grit is not forced in with grease.
9. Be sure gun is thoroughly cleaned before changing type of grease.
10. Keep your machine clean always.

Bucyrus-Eries are the finest excavators that modern engineering can build. Good lubrication regularly, carefully and cleanly applied will protect their easy, smooth, high speed operation in the vital tasks they are performing in winning the war.

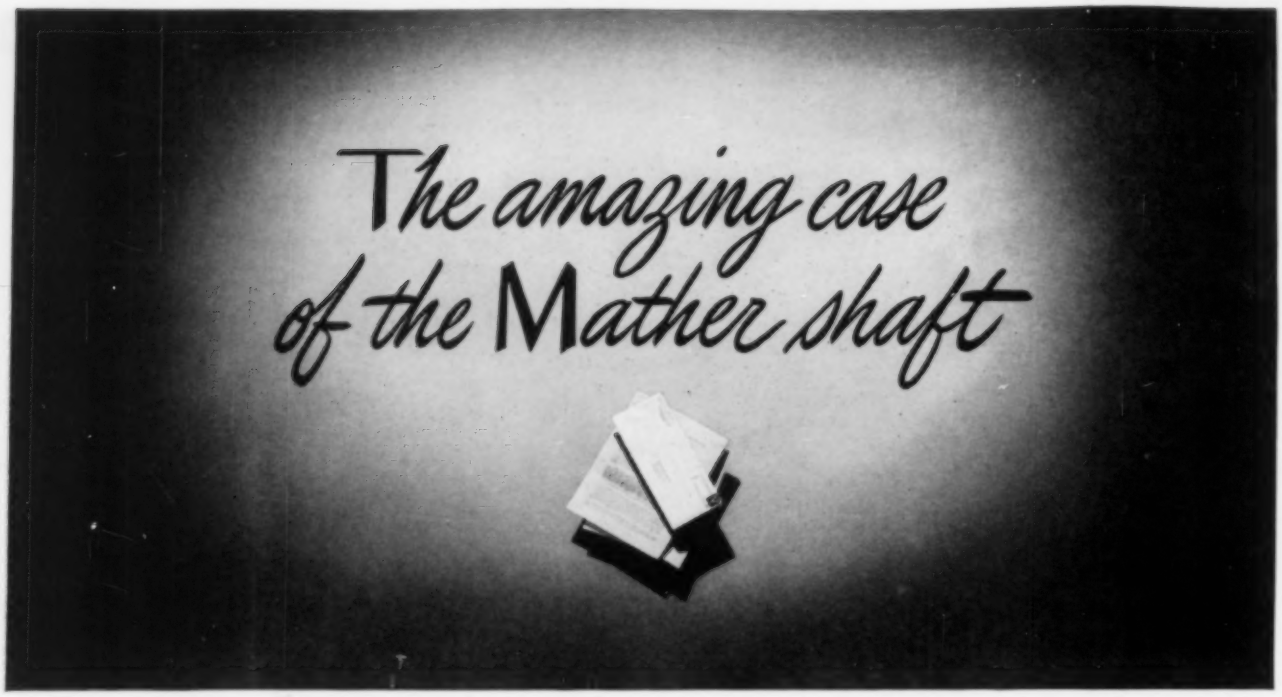
V-21

ARMY E NAVY

Bucyrus-Erie employees have accepted the award of the Army-Navy "E" as a challenge to keep production rising. ★ ★

Bucyrus-Erie

SOUTH MILWAUKEE • WISCONSIN • U. S. A.



THROUGH 2352 FT. OF ROCK WITH 94 FEET OF DRILL STEEL

Here is a letter we recently received from C. W. Allen, Superintendent of the Mather Mine of the Cleveland-Cliffs Iron Company, Ishpeming, Michigan. This letter is so specific in detail, and so amazing in content, that we are printing it just as received. No comment is necessary. Mr. Allen writes as follows:

★ ★ ★

"The story of the Bethlehem Hollow Drill Steel used in sinking the Mather shaft is so good that the facts seem unbelievable. Actually we have used less than 100 ft. of 1-inch quarter octagon drill steel in sinking a distance of 2352 ft.

"Shaft sinking was started in surface material on January 6, 1941, and resumed at a depth of 107 ft. on April 1 in rock after concreting into ledge. The average progress thereafter was a little more than 100 ft. per month, and the shaft was bottomed on January 12, 1943 at the above-mentioned depth of 2352 ft. The rock formations encountered in the sinking were diorite, jasper, slate, and quartzite. The drill machines were 65-lb. sinkers. The depth of cut ranged from 4 ft. to 10-1/2 ft., the average being 6 ft. Approximately 70 holes were drilled in the shaft bottom for each blast, and this resulted in a total of about 161,000 ft. of drill hole put down in sinking the shaft.

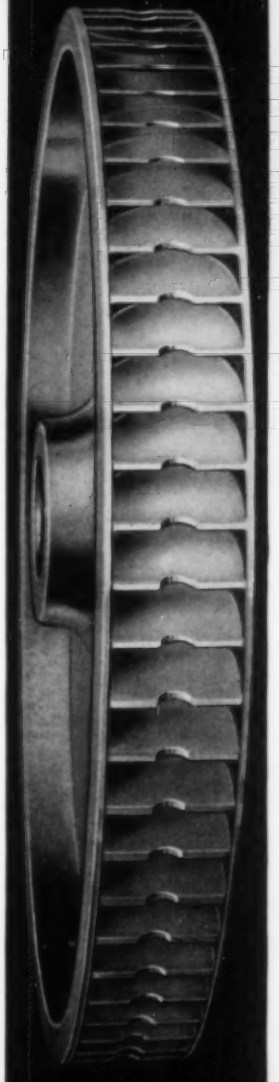
"The hardness of the rock varied considerably. The average number of detachable jack bits needing regrinding after a blast was about 300, but this ran to an extreme in the hard blue jasper of 1500 to 1700 regrinds after a 4-ft. cut.

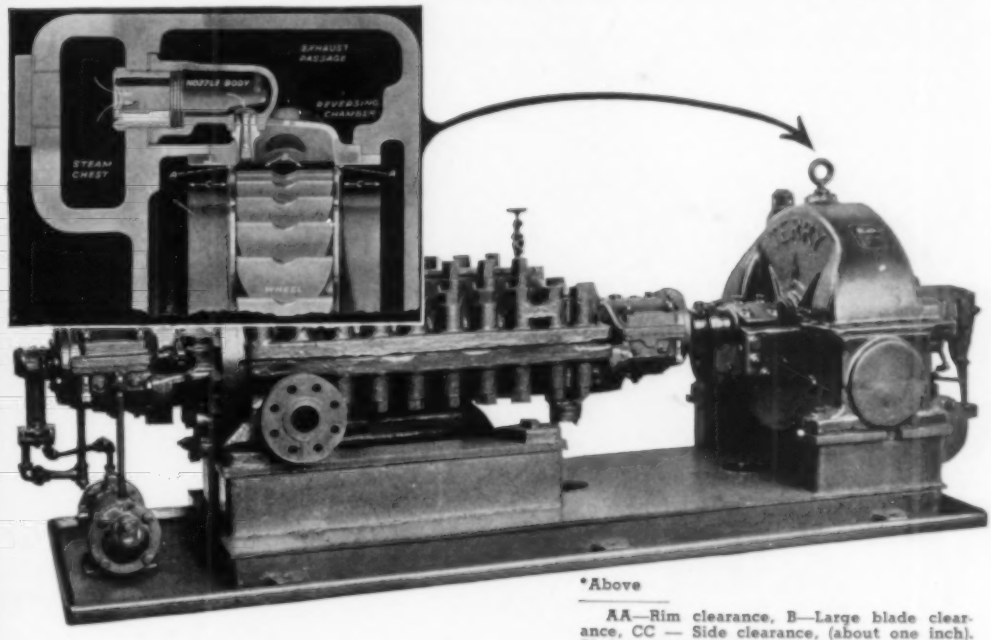
"Two complete sets of steel were made up in our shops, one with Type "0" thread and the second with Type "1" thread. The total lengths were 1830 ft. of Type 0, and 2196 ft. of Type 1. These two sets were maintained during the sinking, cutting off about 2 in. at the thread end as the threads became worn. New threads were then cut, the shank ends were squared with a cut-off machine, and the steel retempered in an electric furnace. The latter, we believe, periodically relieved fatigue strains and may help to account for the fine performance.

"After the sinking was completed, the steel on hand was measured and as I said before, though it seems impossible, we still had in service all but 94 ft. of the original steel. Not to make the story any better, it is probable that the major portion of the 94 ft. was lost in blasting steel which stuck in the drill hole."

BETHLEHEM STEEL

TERRY





*Above

AA—Rim clearance, B—Large blade clearance, CC — Side clearance, (about one inch). Blades cannot foul, as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large that end-play from excessive external thrust cannot damage wheel.

END PLAY WILL NOT DAMAGE THE BLADING OF THE TERRY WHEEL TURBINE

In the Terry Wheel Turbine the blades are protected by rims at the sides of the wheel, which would take without damage any rubbing that might occur if the clearance became reduced. With this construction it is impossible for the blades to foul and frequent inspection of the thrust bearing is not required to obtain safe and dependable operation.

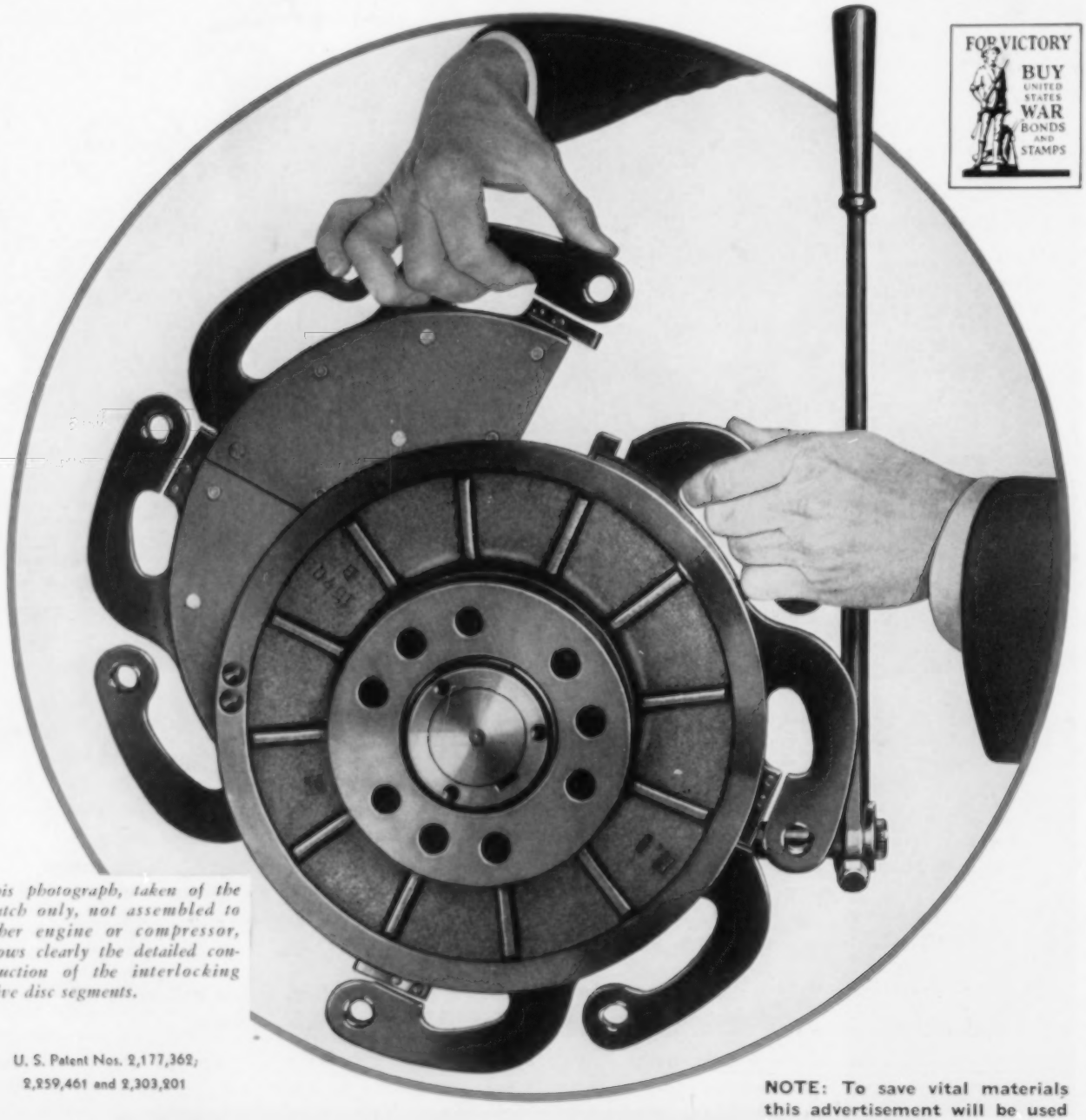
The Terry Wheel Turbine is fully described in our Bulletin S-116. A request on your business letterhead will bring a copy.

T-1133

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

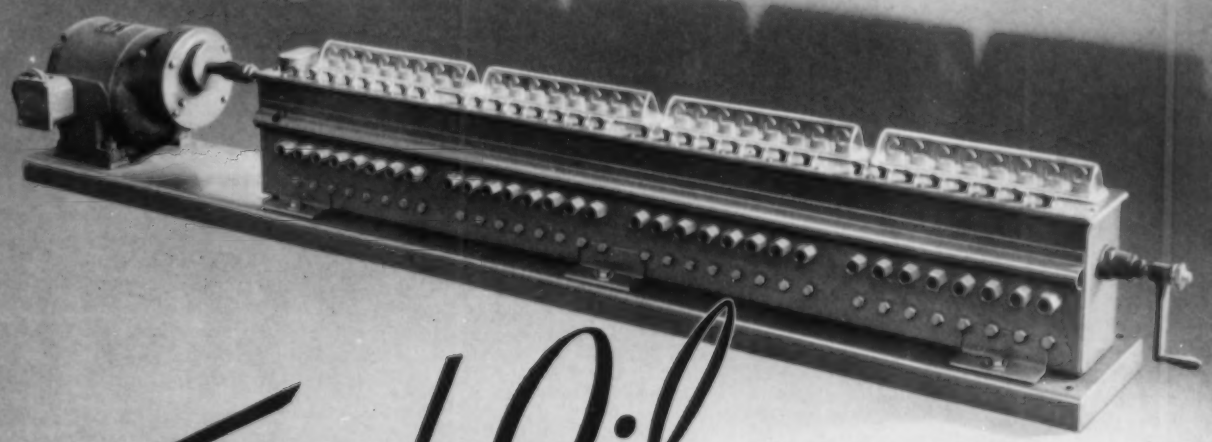
NOTE: To save vital materials this advertisement will be used for "the duration."

C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

MADISON-KIPP LUBRICATORS

Keep Rolling Mills Rolling



Fresh Oil FED UNDER PRESSURE BY THE MEASURED DROP

THE MOST DEPENDABLE METHOD OF LUBRICATION EVER DEVELOPED

Madison-Kipp motor driven units in almost any size and for almost any oil delivery requirement can be provided and in several different models.

Rolling mills, forging machinery and batteries of machines that work in unison are often best lubricated from a central source. Conventional automatic cut-in and cut-out controls may be applied.

Madison-Kipp specializes in original standard equipment lubricators. When you buy new machinery it will pay you to specify Madison-Kipp . . . the most dependable method of lubrication ever developed.

Sole Agent in England: Wm. Coulthard & Co., Ltd., Carlisle

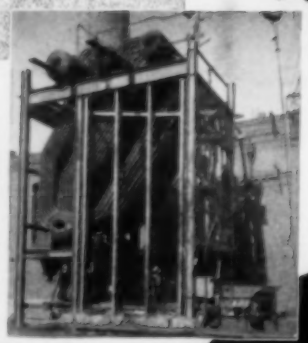
MADISON-KIPP CORPORATION 202 WAUBESA STREET MADISON, WIS., U.S.A.

Vogt PRODUCTS ARE

★ DESIGNED to RAISE
★ OPERATING STANDARDS and
★ LOWER YOUR COSTS

Drop Forged for Safety and Economy under the Most Trying Conditions

Valves, Fittings and Flanges by Vogt—the choice of operating men everywhere for safe and sure regulation of the high pressure and high temperature liquids and gases used in modern process work.



High Operating Efficiencies and Low Maintenance Costs

More steam per dollar of investment—because Vogt steam generating equipment is designed and built to fit in with specific operating conditions. Vogt boilers are available in bent tube types and straight tube, forged steel sectional header types for solid, liquid, or gaseous fuels, as desired. Three-drum types can be supplied to fit any conditions of restricted installation space.

Meeting the Demands for Operating Security

Vogt has every facility for the fabrication of stills, towers, continuous rotary filters, filter presses, oil chilling machines, heat exchangers, etc., and these products are serving the petroleum industry around the world.

Vogt PRODUCTS

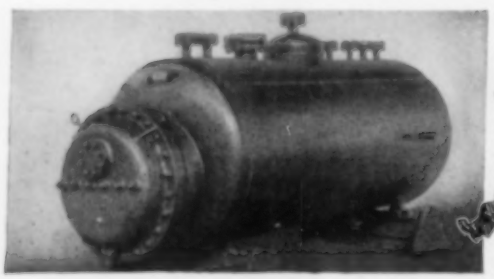
For Oil Refineries, Chemical Plants, Power Plants and Related Industries

☆

HENRY VOGT MACHINE CO.

LOUISVILLE, KENTUCKY

NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO • DALLAS

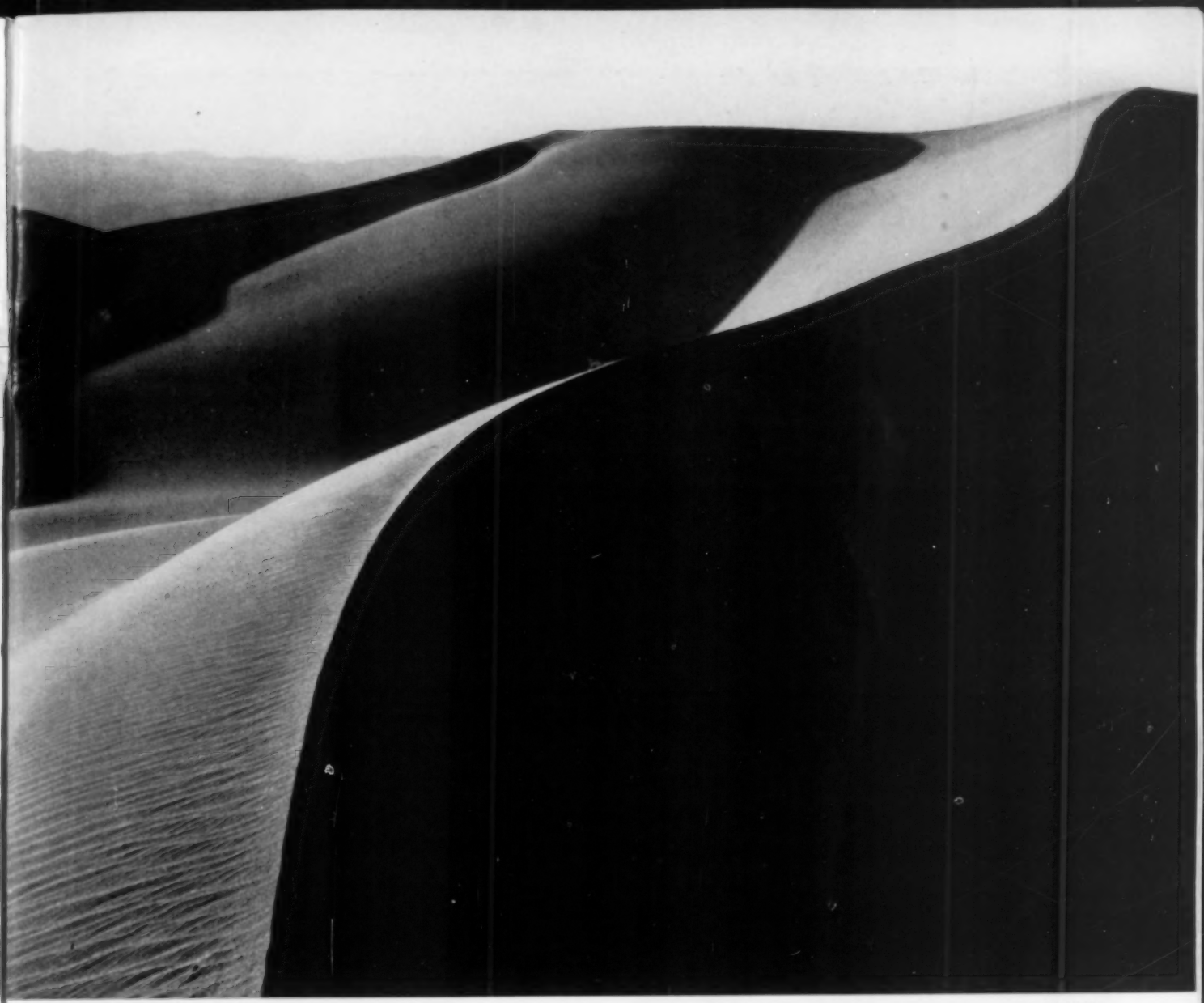


To Combat Corrosion and Product Contamination

Process equipment made from special metals and alloys for the exacting service of the chemical plant is fabricated in our modern shops for many of the well known chemical companies.

Steps Tonnage Up and Costs Down

Our experience of more than 50 years in building profit-making ice and refrigerating machinery is at your command. We make complete units for ice and cold storage plants, packing plants, dairies, breweries, chemical plants, oil refineries, etc.



EWING GALLOWAY

AIR POWER

Think what a tremendous job it would be if you had to move a sand dune with a shovel and a wheelbarrow. Yet, when the desert winds are blowing, the sand dunes are continually shifting. Such is the power created by pressure differences in the atmosphere.

When the pressure differences are machine-made this remarkable form of power becomes *compressed air*. Used in many, many ways for industrial and processing purposes, this form of power has benefited mankind tremendously. Air compressors in thousands of sizes are producing millions of *air* horse-power for production and fighting fronts.

One of the most important uses of *compressed air* is the operation of **air tools** used by our nation's war industries. These tools are in such universal use because they are light in weight, durable, safe, easy to handle, and packed with a power that is easily regulated . . . all features enabling workers to improve their skill and increase production.

Industrial production problems require an assortment of *compressed air* equipment. Ingersoll-Rand has available many sizes and types of **air tools** for your selection. We also offer a complete line of compressors to supply air for countless other uses.

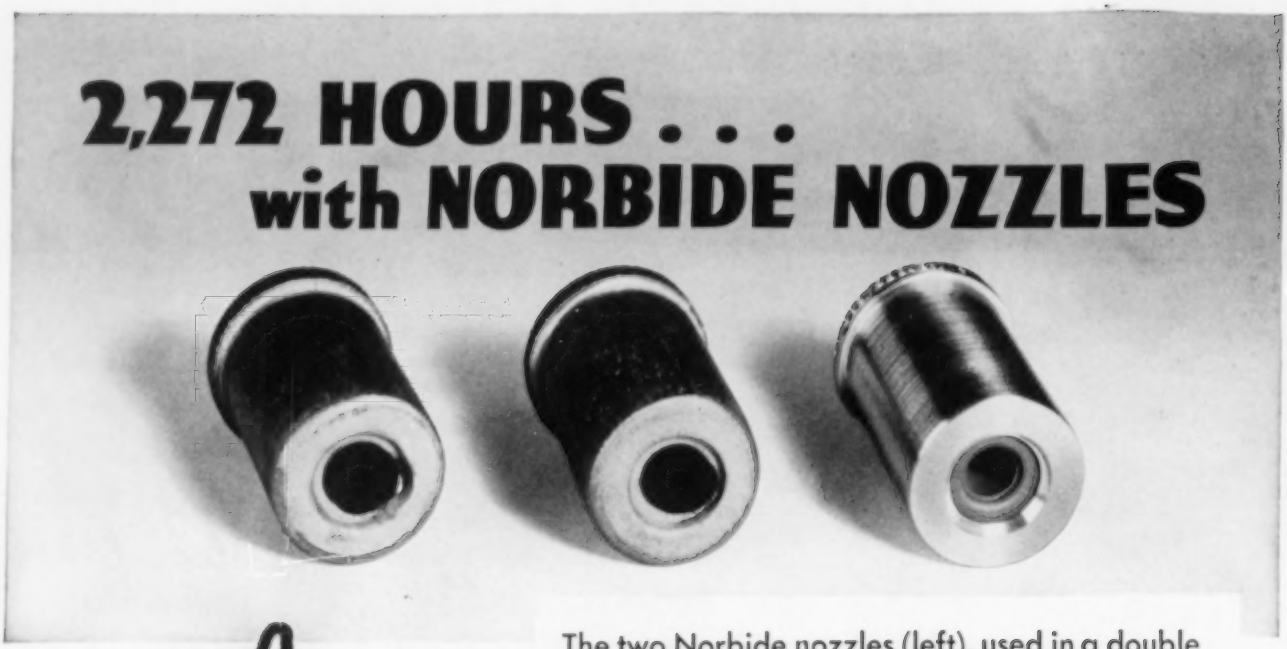
Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.

B-500

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

2,272 HOURS . . . with NORBIDE NOZZLES

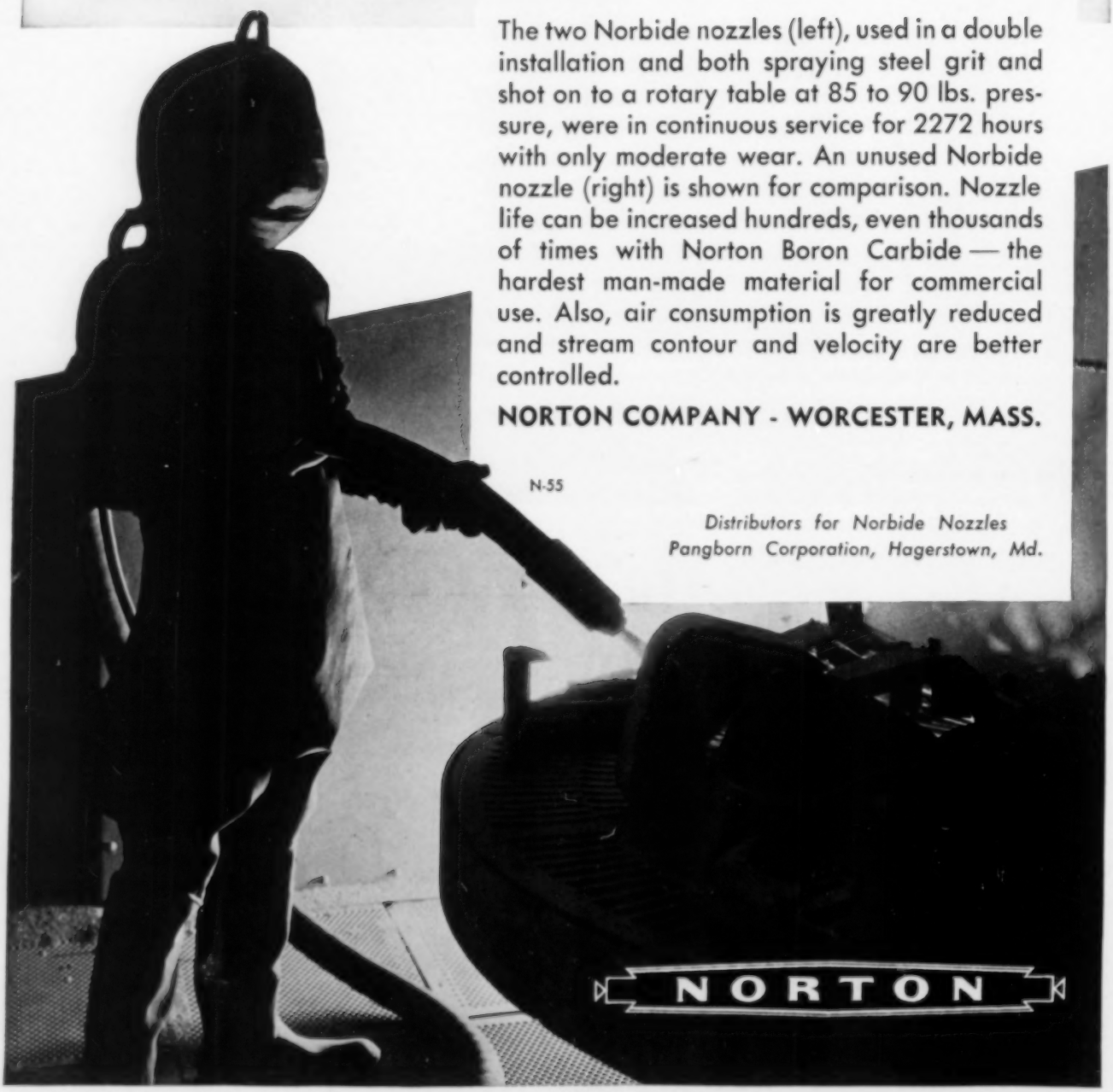


The two Norbide nozzles (left), used in a double installation and both spraying steel grit and shot on to a rotary table at 85 to 90 lbs. pressure, were in continuous service for 2272 hours with only moderate wear. An unused Norbide nozzle (right) is shown for comparison. Nozzle life can be increased hundreds, even thousands of times with Norton Boron Carbide — the hardest man-made material for commercial use. Also, air consumption is greatly reduced and stream contour and velocity are better controlled.

NORTON COMPANY - WORCESTER, MASS.

N-55

Distributors for Norbide Nozzles
Pangborn Corporation, Hagerstown, Md.



ON THE COVER

PARTICIPATING in a national movement among periodicals, we grace our front cover with a color reproduction of Old Glory, flying proudly in the breeze.

•

IN THIS ISSUE

TUNGSTEN is a miracle metal during wartime. A cutting tool of tungsten-alloy steel will keep doing its work even when red hot. Obviously, then, in this war of production, tungsten is a vital element. In normal times much of our tungsten comes from China. When its supply was shut off, new foreign sources had to be developed to supplement domestic production. Foremost among these is Bolivia, where tungsten often exists in association with tin ore. Our leading article tells the story of Bolivian tungsten mining, in which traditional manual processes are now being aided by modern mechanical methods.

•

IN JANUARY, 1942, it took an average of 241.6 days to build a Liberty Ship. In December of the same year, 82 of the vessels were delivered and the average time required to construct each of them was 55 days. The current average record from keel-laying to delivery is even less. This tremendous acceleration in speed is attributable in part to a system of prefabrication by which sections are built and then put in place. Eighteen shipyards are now engaged in turning out Liberty Ships, officially known as Emergency Cargo vessels. One of the new yards commissioned in 1941 is that of the North Carolina Shipbuilding Corporation at Wilmington, N. C. An article by Robert G. Skerrett describes its facilities and traces the principal steps in the construction of a Liberty Ship.

•

TWENTY-FIVE hundred years ago a man from Megara, Greece, named Eupalinos drove a tunnel through 3,300 feet of rock on the Island of Samos, near the coast of Asia Minor. It was perhaps the first bore of that length ever built. The obstacles that had to be overcome must have been tremendous, for rock drills, blasting powder, ventilating machinery and other modern tunneling aids were unknown. The story of the tunnel's construction and its significance, as pieced together by modern investigators, is presented in a 5-page article.

•

BEGINNING with this issue, we are reducing our page size slightly. The change will decrease our use of paper per copy by 9 per cent.

Compressed Air Magazine

COPYRIGHT 1943 BY COMPRESSED AIR MAGAZINE COMPANY

VOLUME 48 **July, 1943** NUMBER 7

C. H. VIVIAN, *Editor* J. W. YOUNG, *Director of Advertising*
A. M. HOFFMANN, *Assistant Editor* W. M. HACKENBURG, *Adv. Mgr.*
D. Y. MARSHALL, *Europe*, 243 Upper Thames St., London, E.C.4.
F. A. McLEAN, *Canada*, New Birks Building., Montreal, Quebec.

EDITORIAL CONTENTS

Tungsten from Bolivia—*R. B. Hall* 7073
Building Liberty Ships in Record Time—*Robert G. Skerrett* 7079
India's Contribution to the War Effort 7085
Eupalinos—First Civil Engineer—*F. Russell Bichowsky* 7086
Birdproof Windshields for Airplanes—*R. N. Bryan* 7091
Protective Device for Small Motors 7092
Hollywood Goes Subaqueous 7093
Salvaging Waste Paint 7094
Editorials—Ship Tonnage Defined—Postwar Planning 7095
Log of Our War Economy 7096
Scrap Saves Man-Hours 7097
Air-Operated Impact-Type Stamping Machines 7097
Industrial Notes 7098

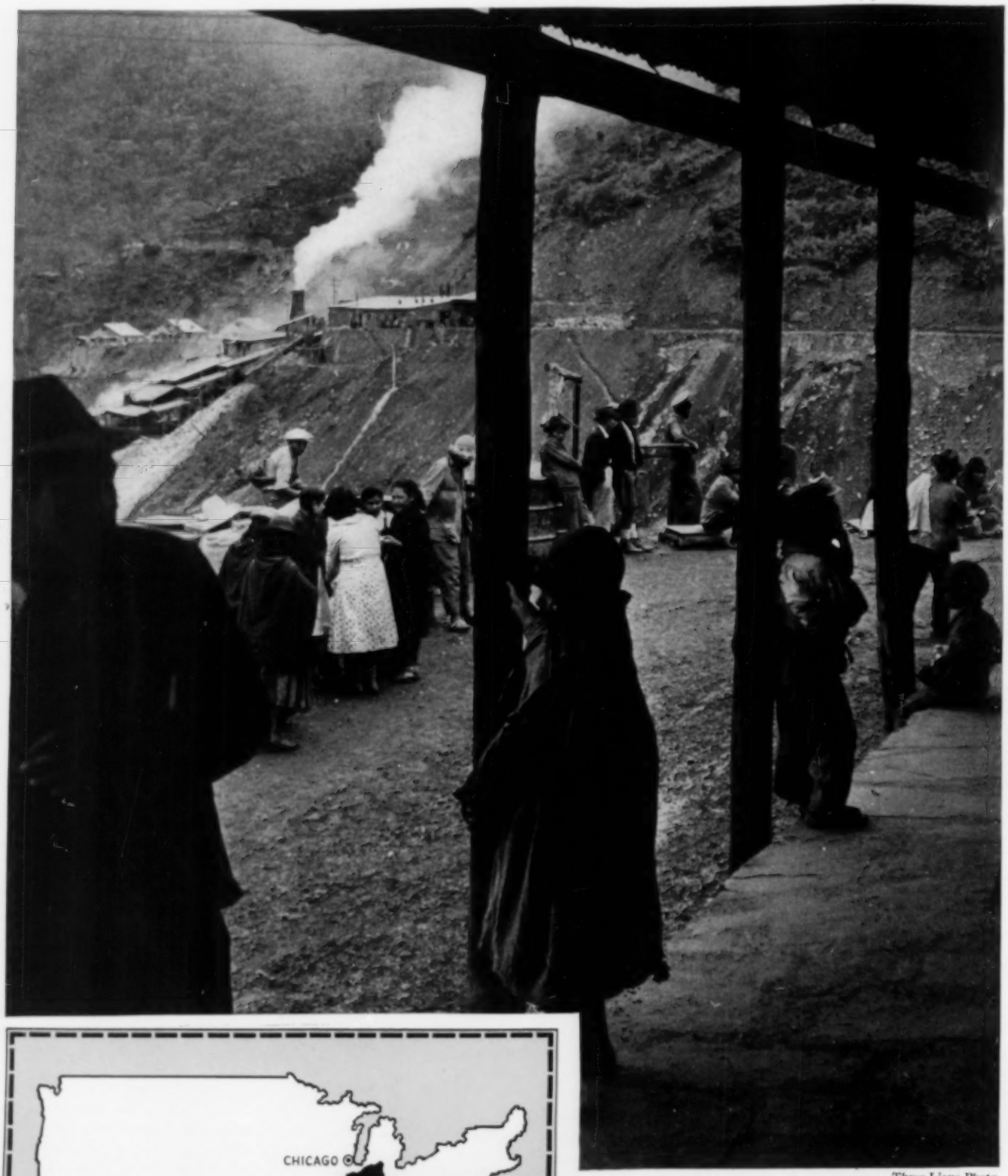
ADVERTISING INDEX

American Hoist & Derrick Co. 26
Bethlehem Steel Co. 12
Bucyrus-Erie 11
Business Press Industrial Scrap Committee 30
Conrader Co., R. 26
Cook Mfg. Co., C. Lee 32
Coppus Engineering Corp. 2nd Cover
Dayton Rubber Mfg. Co. 7
Eimco Corp., The 4
Elastic Stop Nut Corp. of American 4th Cover
France Manufacturing Co. 21
Galland-Henning Mfg. Co. 28
General Electric Co. 31
Hercules Powder Co., Inc. 10
Industrial Clutch Co. (C. M. Eason) 14
Ingersoll-Rand Co., ..8, 17, 22, 29
Koh-I-Noor Pencil Co., Inc. 30
Lebanon Steel Foundry 27
Logan Engineering Co. 28
Madison-Kipp Corp. 15
Maxim Silencer Co., The 24
Naylor Pipe Company 19
New Jersey Meter Co. 26
Nicholson & Co., W. H. 28
Norton Company 18
Nugent & Co., Inc., Wm. W 30
Socony-Vacuum Oil Co., Inc. 9
Square D Company 20
Staynew Filter Corp. 3
Terry Steam Turbine Co., The 13
Texas Company, The 5
Timken Roller Bearing Co., The 25
Vogt Machine Co., Henry 16
Walworth Company 23
Westinghouse Elect. & Mfg. Co. 6

A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

CCA Member Controlled Circulation Audit.

Published by Compressed Air Magazine Co., G. W. MORRISON, *President*; C. H. VIVIAN, *Vice-President*; F. E. KUTZ, *Secretary-Treasurer*.
Business, editorial, and publication offices, Phillipsburg, N. J.
Advertising Office, 11 Broadway, New York, N. Y., L. H. GEYER, representative.
Annual subscription: U.S., $3.00; foreign, $3.50. Single copies, 35 cents.
COMPRESSED AIR MAGAZINE is on file in many libraries and is indexed in Industrial Arts Index.



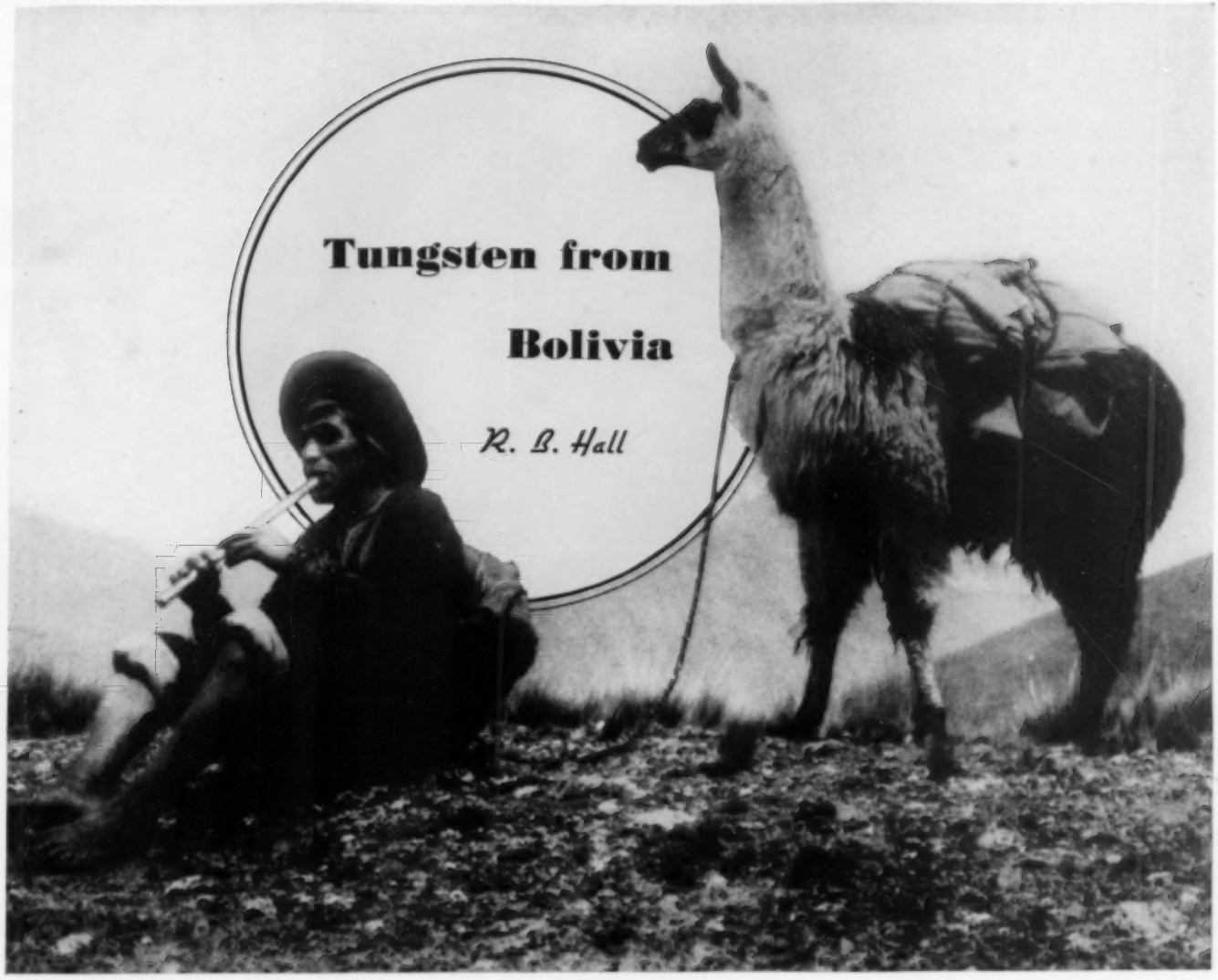
Three Lions Photo

AT THE CHOJLLA MINE

Natives gathered around the "pulperia," or company store, of a tin-tungsten property operated by the International Mining Company, a subsidiary of W. R. Grace & Co. of New York. The mill is in the background. This mine is in the Yungas district and, unlike many others in Bolivia, is at a low enough altitude (7,000 feet) to have the advantage of timber for firing roasting furnaces. The journey from La Paz to the mine entails the crossing of mountains 16,000 feet high on narrow roads.

Tungsten from Bolivia

R. B. Hall



M. L. McCormack Photo

SHEEP OF PERU

That is the name originally given the llama, traditional beast of burden of upland South America. Llamas still haul some of the supplies to isolated Bolivian mining camps and take out ore or concentrates. The llama is a domesticated derivative of the guanaco, and is the larger of two members of the camel tribe that are indigenous to South America. This animal eats little, and is almost the equal of the mule in sure-footedness and endurance. It can go four or five days without water but, paradoxically, has the annoying habit of spitting, especially when displeased, and its saliva has an unpleasant odor. The picture shows a shepherd and a llama in a highland setting.

ALL the continents of the world have been commercial producers of tungsten at some period in their history. Probably because of the mineral's importance in warfare, many countries have encouraged mining of the ore despite the lower cost of imported concentrates. Before the first World War, Burma and the Federated Malay States were by far the largest producers. Under the impetus of that conflict, tungsten mining gathered momentum in North America, South America, and especially in China. The sharp decline in supplies from China within the past two years has been relieved only in part by stimulated output in the United States, Bolivia, and Portugal. Argentina is becoming an increasingly important source of that vital mineral, although Bolivia is by far the largest contributor in Latin-America and probably ranks third among the major producing countries.

Tungsten is perhaps best known to most people as the metal of which filaments for incandescent lamps are made. Both wolframite and scheelite were originally thought to be ores of tin and were once called tungsten, meaning "heavy stone." Late in the eighteenth century, two Spanish chemists produced metallic tungsten for the first time, and subsequent research has revealed that it possesses many desirable properties. It has the highest melting point of any of the metals; and because of its hardening effect on other metals with which it can be alloyed it is in wide demand for the manufacture of metalworking tools. For such purposes it is usually employed either in the form of high-speed tool steels or of cemented carbides, which are used for making the tips of cutting tools and also hard dies. Of comparatively recent development are new types of steel in which the tungsten content is reduced, the deficiency being largely offset by the addition of molybdenum. In general, tungsten is the principal component of steel that is required to have heat-resisting and noncorrosive properties, while the development of tungsten carbide has made possible the manufacture of tools with tips harder than any other material save the diamond. These are widely used for machining steel and other metals, and possess the virtue of retaining their cutting edges even when red hot.

Tungsten is vital to the war effort because it is indispensable for the making not only of cutting tools but also of cores for armor-piercing shells and of erosion-resistant liners for heavy ordnance, armor plate, and gun breeches. Other equally

important uses include the manufacture of surgical instruments, electrical contacts, radio and telephone equipment, permanent magnets, and X-ray targets. There are many other applications, but these are sufficient to explain why it is rated as a critical metal by the War Production Board.

The importance of Bolivian tungsten to the United States became evident when Japan's invasion of China began to disrupt shipments from the latter country. In the past, most of our importations came from China, which has accounted for as much as 70 per cent of the world's output in a single year. When the supply from there dwindled, the Metals Reserve Company signed contracts for Bolivia's entire tungsten-ore production for a period of three years starting July 1, 1941. Before the outbreak of the present war the United Nations controlled 95 per cent of the world's tungsten resources. Today, because of enemy action, only 35 per cent is available to them. According to *Mineral Trade Notes*, published by the U. S. Bureau of Mines, records of Bolivian tungsten production date back to 1908, and the yearly output from 1908 to 1914 averaged 265 tons of concentrates with about 60 per cent WO_3. During World War I, production was boosted to 3,500 tons yearly by reason of the unusual demand for the metal and tripling of the prewar price, and 75 per cent of the concentrates was then shipped to the United States.

The postwar years brought about the collapse of the tungsten market, and exports from Bolivia sagged to less than 500 tons of concentrates annually until 1932. From then on to 1941 there was a rise of 600 per cent in exports, with 2,880 short tons shipped in 1941. During 1936, 1937, and 1938 Belgium imported 4,279 short tons of tungsten concentrates from Bolivia, or nearly 62 per cent of her total exports—6,918 tons. Most of this was probably reëxported to Germany. During 1940 Japan became an important market for Bolivian tungsten and antimony, in some cases paying better prices for dirty concentrates than the United States paid for clean concentrates. This is interesting in view of the fact that China is rich in both these minerals, and Chosen (Korea) ranks high among the world's largest producers of tungsten. Now, not only are all of Bolivia's tungsten resources available to the United Nations, but also her tin, lead, copper, antimony, zinc, and other mineral reserves. Moreover, the republic has mobilized her manpower so as to increase output and to assure the movement of a steady supply of ore to the war plants of those nations.

At this point it is interesting to discuss some of Bolivia's physical features because of the transportation difficulties they impose. The country lies inland and is surrounded by high mountains, tropical jungles, and virtually uninhabited plains. Much of it is situated on the Altiplano—a plateau 12,000 feet above sea level and 6,500 square miles in area. This highland is situated between two great chains of the Andes that run north and south. But despite its semi-isolation, Bolivia has long played a part in world affairs, a paradox that can be explained largely by her mineral wealth. These riches lured the Spaniards to the region in the sixteenth century; and that their hopes were realized is proved by the fact that the treasure from her mountains financed the military campaigns which enabled imperial Spain to conquer much of Europe. Now, 400 years later, minerals from the same source are aiding the United Nations in their struggle against military aggression.

Bolivia is linked by rail with Pacific ports in Peru and Chile and with Argentina to the south. From the Atlantic side the country is reached by an arduous 2,000-mile journey up the Amazon and the Madeira rivers. Highways connect the principal cities, but pack animals and old, winding trails are the principal means of transportation in the mountainous interior. Commercial aviation is being developed to meet the wartime need for im-

NATIVE WORKERS

Until very recently, hand methods were used to mine and mill at least half of Bolivia's tungsten output, and they are still relied upon to a large extent. These pictures were taken at the Chojlla (pronounced Choke-ya) Mine. The cheek of the miner below is distended by a quid of cocaine-bearing leaves of the cola plant, which the natives chew to give them endurance. In the center is a crude crusher called a "quimbalete." After the ore has been crushed, jigs and tables remove most of the worthless vein material, after which women separate the tin and tungsten minerals (left). The resultant concentrates are roasted to remove arsenic and sulphur and are then shipped to a refinery.

Three Lions Photos.

proved communication between the high Andean region and the rubber- and food-producing areas to the north and east, and is especially suitable because Bolivia's industrial centers are located on the Altiplano. One important phase of this program is the construction of an airport at Cochabamba that will be among the best in South America. Also included in the project is the improvement of airfields already in use. Some of these are unique in that they have runways from 2 to 3 miles long. Because of the rarified air at high altitudes they have to be of sufficient length to permit long runs for the take-off, as well as ample room for landing at speeds higher than are necessary at lower altitudes. The airport serving La Paz is situated at an elevation of more than 13,000 feet. The risks involved are naturally greater than they would be under ordinary conditions and apply to most of the air lines maintained in South America. It is therefore to the credit of Panagra (Pan American-Grace Airways) that it did not have a passenger fatality during the 5½ years ending January, 1943. Until fairly recently, most airlines serving Bolivia were under German control.

The basis of Bolivia's economy is mining, and minerals comprise 90 per cent of her exports. The importance of the mining industry is indicated by the fact that it employs an estimated 70,000 persons out of a population of 3,457,000. The Banco Minero de Bolivia, a modern banking institution, has been and is of invaluable assistance to the industry. The producers are classified as large, medium, and small, and it was to assist the operators of the latter that the Banco Minero was primarily created. Expansion of its functions subsequently enabled it to purchase exclusively the output of the medium and small mines, and, as specified in contracts with the Metals Reserve Company, is exporting the minerals from those sources. An added service rendered by the bank, and a most important one, is that of extending credit and of supplying explosives, tools, and machinery to the mines.

Most of the tungsten mines are from 12,000 to 15,000 feet above sea level, and since the country is sparsely populated, the local labor supply is limited. In most cases the workers employed—both men and women—are Indians, for they have proved to be the only ones that can stand up under local conditions; labor imported from lower altitudes is usually inefficient. Until recently at least half the tungsten and practically all the antimony in Bolivia have been mined and milled by hand methods. Since nearly all the available labor has been absorbed by the mining industry, increased production depends upon mechanization. In the past, capital has been discouraged from investing in tungsten mining largely because of the uncertainty of the market for the ore, and this single factor has been mainly responsible for the lack of modern equipment. Now, however, because of the great demand for the mineral, mines are installing machinery to speed up production and development work.

According to *Mineral Trade Notes*, the Bolivian tungsten ores occur throughout the tin belt, though usually in separate deposits. The principal mines are in the Department of La Paz, with smaller workings in the Departments of Oruro and Cochabamba. Wolframite is the most common mineral, although scheelite is also prominent in a few of the localities. In general, both the geological features and the mode of occurrence of both the tungsten and the tin deposits are similar. In addition to the operating mines, there are more than 100 known deposits that can boost production. The fact that they have so far not been exploited is, as has

BOLSA NEGRA MINE

Located 40 miles southeast of La Paz and at an altitude of 13,500 feet, this mine is really a quarry. The tungsten minerals—wolframite and scheelite—are found in horizontal veins that follow the bedding planes of siliceous slates. Local concentrations form deposits averaging 2.5 per cent tungstic oxide, and these are mined by potholing the face of a cliff at various locations where they outcrop. The ore is mined and sorted by contract labor, after which it is crushed and concentrated to form a product containing 67 per cent tungstic oxide. Last August the rate of production was increased to about 350 tons of concentrates annually.

already been emphasized, attributable to the lack of capital, trained mining engineers, mechanization, and improved transportation; to incomplete geological information; and to the uncertainty of postwar markets. All these factors are interrelated and are of great significance to the mining industry as a whole. The larger properties that are being operated account for about half of the tungsten output, and the mining and ore-dressing methods employed are relatively efficient.

The mines are worked from adits, some with internal shafts and levels well spaced and connected by raises. Cut and fill is the usual procedure, because this permits the sorting of rich ore and waste in the stopes. In some localities only the richer portions of the veins are mined, the stopes being left open. High-grade ore, when found, is worked and sacked separately. Most of the miners work by the day, usually in 8-hour shifts, but in the case of the smaller properties they are often under contract, the owners paying them according to the number of 100-pound sacks of concentrate they produce. Each 100-pound bag is known as a *quintal*. There is no such thing as a mining system in the smaller workings. Adits are driven along the veins, and when ore is encountered it is usually gutted out and the stope left empty. These adits and drifts frequently have steep grades—a fact that makes underground transportation difficult, depending as it does upon wheelbarrows.

The ore-dressing plants at the big mines consist of hand-sorting floors, a rock crusher, a set of rolls, an elevator, a trommel, and of jigs and tables for concentrating the coarse sizes and the fines, respectively. Sulfides are often present in the ore, and the concentrates are roasted in a small reverberatory furnace to eliminate the sulphur and arsenic. The resulting iron oxide is removed by a magnetic separator. Sometimes flotation units are used in place of roasting to eliminate the sulphides. Metal recovery generally ranges from 45 to 75 per cent, and the grade of the concentrate averages about 60 per cent WO_3 . Metal losses can probably be reduced by improved methods and equipment.

At the smaller mines, concentration is ordinarily done manually. The sorting floor is usually near the mouth of the lowest adit, and there the native women sort the richer ore from the waste material. Hammers are used to break pieces of ore and rock for further sorting. The remaining poor ore is delivered to a hand crusher called a *quimbalete*, which weighs in the neighborhood of 500 pounds. It is nothing more than a large symmetrical rock, flattened on the bottom, with a wooden handle lashed across the top. The handle serves as a lever, and two men, one on each side of the *quimbalete*, rock it back and forth, thus breaking up the ore placed for the purpose on sheet iron or some other hard surface. After being screened to less than ¼-inch size, the crushed ore is passed through hand jigs which produce a coarse concentrate. The fine material that drops through the jig screen then settles in the jig box, where it is concentrated in a trough, about a foot wide, into which flows a small stream of water. The women work this fine material by hand, continually pushing it upstream against the current until it has been sufficiently concentrated.

Despite the importance of mining to Bolivia, experience during the last World War has taught that country the danger of depending too much upon this industry as the foundation of her economic structure.

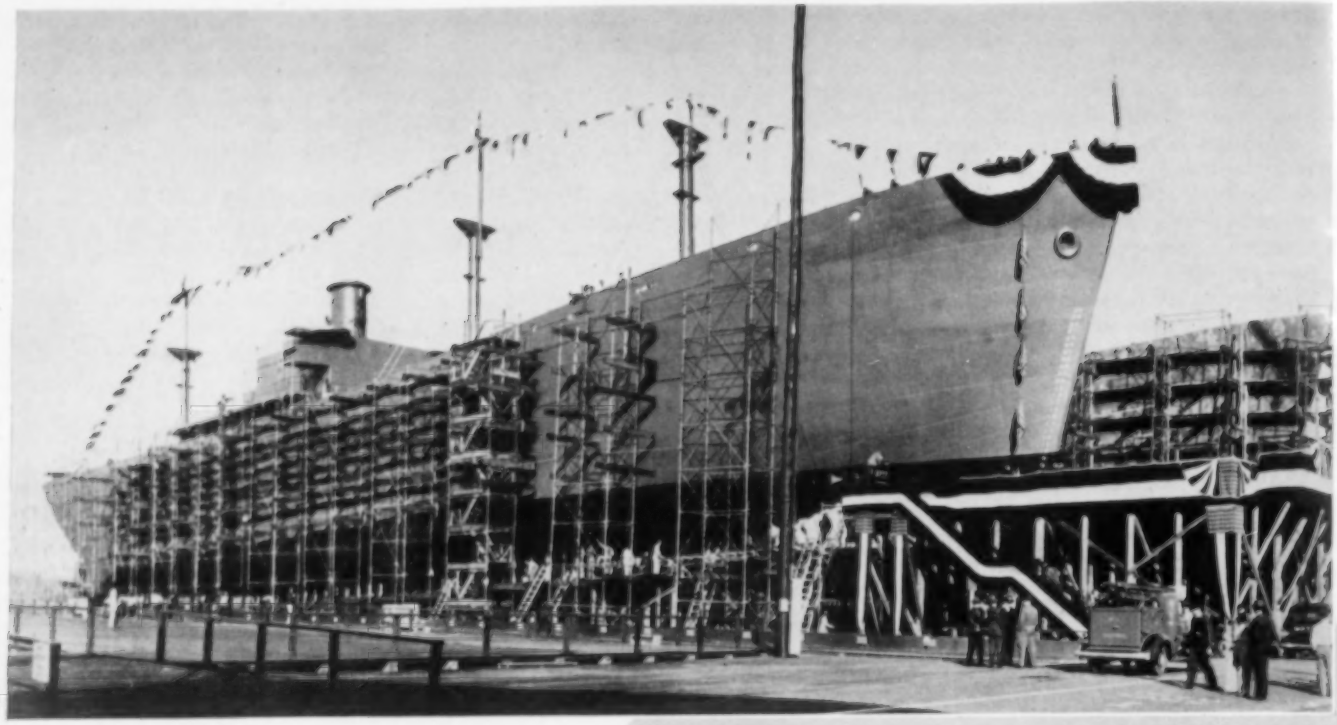
Mining has been fostered at the expense of cattle-raising, agriculture, and other industries, so that Bolivia is forced to import even such necessities as flour, rice, sugar, beef, textiles, lumber, etc. However, under a coöperative arrangement with the United States, Bolivia has undertaken one of the broadest programs of economic development in her history. One of its major features has been the establishment of the Bolivian Development Corporation, a government agency that is supported by technical aid and credits from the United States. The Export-Import Bank of Washington has entered into an agreement to provide a fund totaling $15,000,000 to supplement capital contributed by Bolivia. Among the objectives of the program are increased food production and the extension of highways to link the food-producing regions with the mining country.

The chief farming sections of Bolivia are the deep valleys which divide the Altiplano. Although crude implements are still being used by the Indians, modern equipment and irrigation are gradually being introduced. Agricultural exports from Bolivia include coffee, dried fruits, nuts, cocoa, rubber, and cinchona bark. In addition, fairly important quantities of wool, hides, and petroleum are sent abroad. However, none of these commodities ranks with tin, which alone accounts for 78 per cent of the value of all Bolivian exports. Offering further opportunity for the expansion of her export trade is the United States' demand for tropical materials, notably rubber and quinine, that are urgently needed in her war effort. Bolivia has agreed to sell to the United States Rubber Reserve Company until the end of 1946 all the rubber she produces each calendar year, except 250 tons which goes to Argentina. In return, the United States is providing funds and equipment for the development of the rubber industry and for health and sanitation services for rubber tappers. Doctors and sanitation engineers have already been sent into the remote areas of the lowlands to set up health centers and medical outposts.

By reason of the stimulus of war demands and plans now underway for present and postwar expansion, Bolivia's export trade holds promise of a bright future. With established markets for her raw materials and products, that country will not easily give up the important position that she has attained, as was the case after the last World War. On the contrary, the expectations are that the next decade will be a turning point in the economic life of the republic as a result of the continued development of her natural and industrial resources.

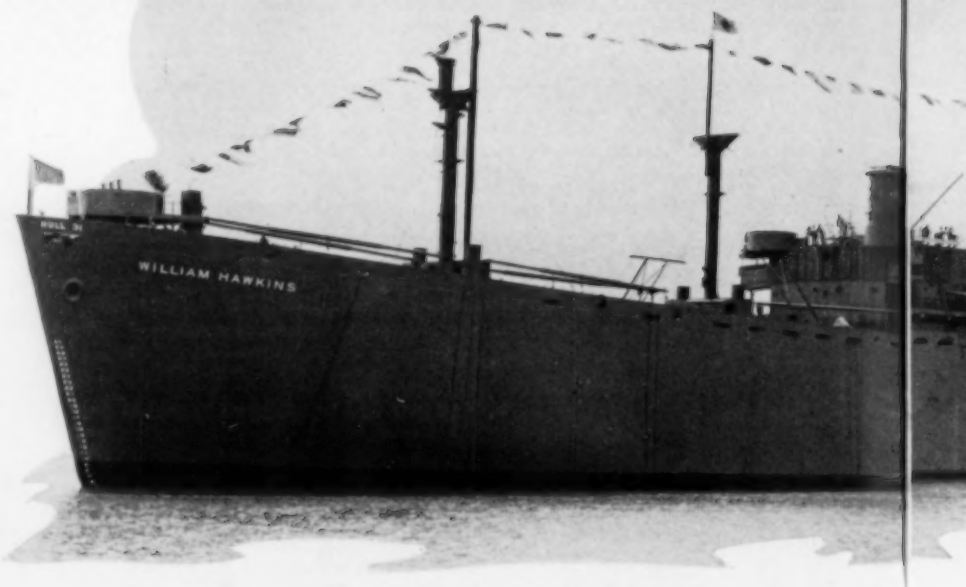
URANIA MINE

This is a tin and tungsten property located 14,000 feet above sea level on a slope of Mount Illimani, which forms the background of the picture at the bottom. It has been worked on a small scale for several years, and production was recently increased following important discoveries of new deposits. It is reported that one vein is 13 feet wide and contains 1.5 per cent tungstic oxide and 1.4 per cent tin. Under the crude milling methods formerly used recoveries were low, but a new plant was erected last year to improve the milling practices. The concentrates are sent to the United States for refinement. A new road to the property, visible in one of the pictures, was built to facilitate development. Until its completion, the mine was accessible only by trail. The view at the right shows a group of natives moving an Ingersoll-Rand portable compressor up the narrow pathway to the property. In the picture below, Vice-president Henry A. Wallace is shown with George D. Bellows, manager of the Chojlla Mine, emerging from an adit after a tour of inspection during Mr. Wallace's recent South American trip.



Building Liberty Ships in Record Time

R. G. Skerrett



THE story of what has been achieved by North Carolina Shipbuilding Company in turning out a large number of Liberty Ships with increasing speed of production becomes understandable only when one knows something about the situation that confronted the nation about two and half years ago. At that time every qualified seaboard shipyard was crowded to capacity with work on battlecraft and on vessels for our merchant marine, and then the U.S. Maritime Commission received a directive from the President to construct with all possible dispatch 200 freighters to meet a shipping need that was steadily becoming increasingly serious. The vessels were needed to handle, under our own flag, our mounting foreign trade and to bring back to us from other lands indispensable materials obtainable nowhere else.

Faced with an unexpected task, the Maritime Commission called into conference representatives of the nation's leading shipbuilding organizations, together with outstanding naval architects and marine engineers, to help evolve ways and means of dealing with the problem. It was proposed, after careful deliberation, to create seven entirely new shipyards to be sponsored by the most experienced of the established shipbuilding concerns. The directive personnel of each was to consist of a few capable men of shipbuilding background and a limited number of departmental experts and others of proved leadership. The major job of actually constructing the vessels was to rest on the shoulders of such skilled workers as might still be available and upon the far more numerous unskilled hands who would have to be trained for their respective assignments in each yard. How many of us are yet alive to the difficulties that confronted the original shipyards that were awarded the contracts for the initial 200 Liberty Ships, as we have since come to know the vessels officially designated as cargo carriers of the EC-2 Type?

It was in January of 1941 that the presidential order for the first group of Liberty Ships was issued; and it was not until each of the yards had been built and equipped to a considerable extent that any of the keels could be laid. Even

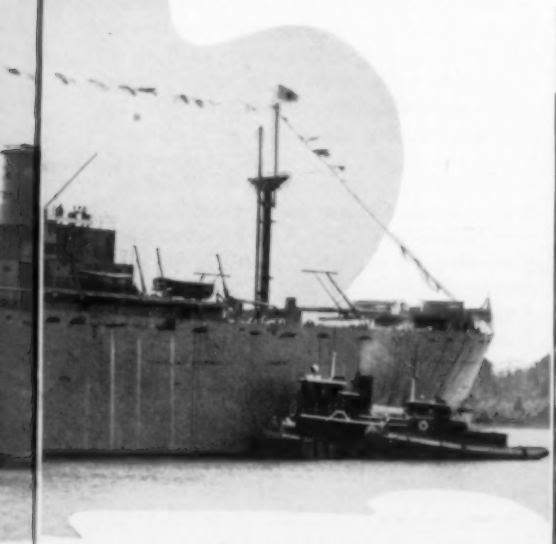
then, months were allowed in which to turn out the first vessel in any of these plants. On January 1, 1942, but one Liberty Ship had been delivered to the Maritime Commission; but by the end of that year the yards engaged in that work had constructed, tested, and made ready for sea service a total of 542 with an aggregate carrying capacity of 5,853,600 dead-weight tons.

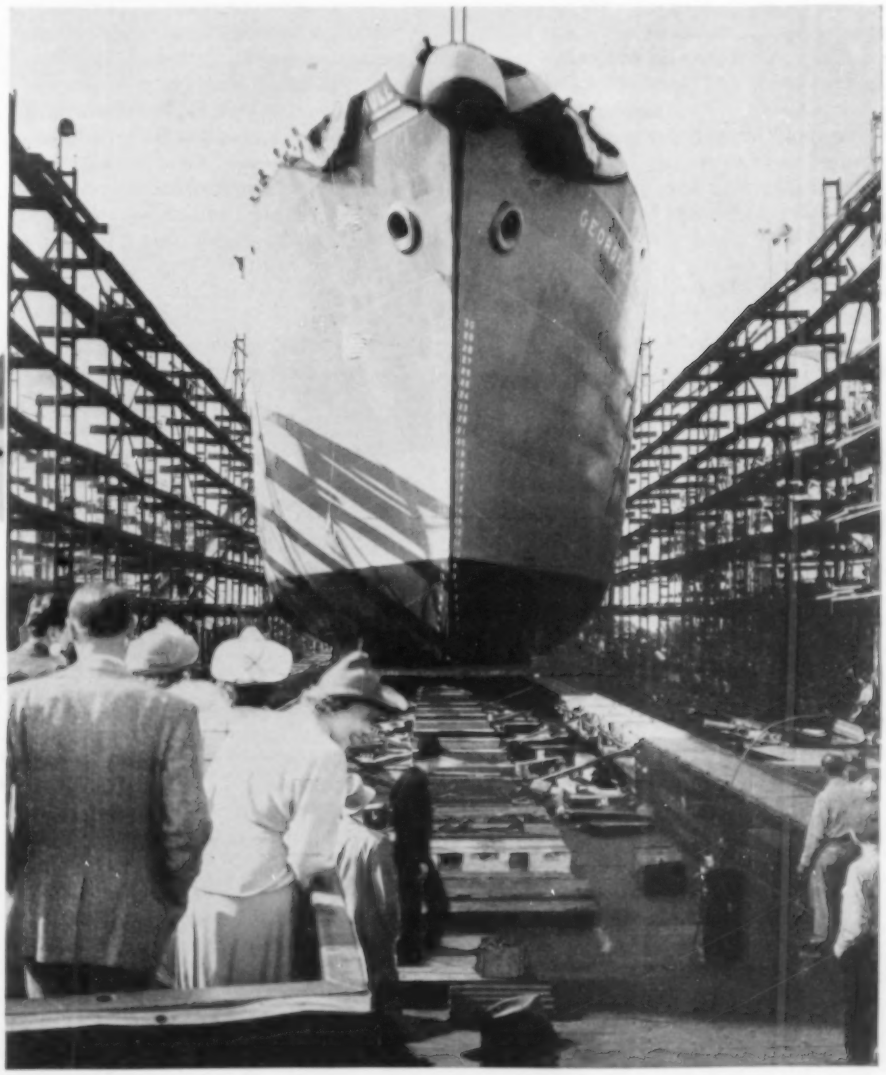
At the start the seven shipyards had, all told, 51 ways on which to lay keels; but shortly after they began operations they were asked by the Maritime Commission to increase the number. Somewhat later, the same guiding organization authorized the establishment of other new yards for the building of Liberty Ships. Today, there are eighteen of them, widely distributed along the Atlantic, Gulf, and Pacific coasts; and more than 800 manufacturing plants, located in 32 states, are supplying materials, propelling machinery, and other equipment for the Liberty Ships. By the close of the present year, these yards will have turned out about 1,500 of the craft for the vitally important work of voyaging to and from ports and bases in all parts of the maritime world. With this done, the people immediately responsible for carrying out the program in force will have made a record of heretofore unapproached accomplishment.

The purpose of this article is to describe what has been achieved by one of the first of the yards called into being in 1941—the plant of North Carolina Shipbuilding Company—which has hung up for itself a record of performance that makes it the foremost among the builders of Liberty Ships on our eastern seaboard and the runner-up for national preëminence in this work by reason of the fact that it is but a few days behind the leading yard in time between keel-laying and delivery. North Carolina Shipbuilding Company was sponsored by the Newport News Shipbuilding & Dry Dock Company, Newport News, Va.; and the parent concern has given the new enterprise the benefit of varied experience in the construction of many different kinds of naval and merchant craft. In all its years of activity, the elder company has made for itself a reputation for progressiveness and excellence of work done. North Carolina Shipbuilding Company has profited by this background.

Early in 1941, the latter company was first given a contract to construct a 6-shipway yard—the Maritime Commission providing $5,140,000 for that purpose. The site chosen for it was a low-lying area on the Cape Fear River several miles downstream from Wilmington, North Carolina's thriving key port. The property leased was largely a marshy expanse that had to be extensively bulkheaded and reclaimed by fill pumped into it by hydraulic dredging while deepening the approaches between the waterfront of the yard and the river channel. The preparatory work was comprehensive, because the shipyard extends along the river for more than a mile, and the total area occupies approximately 165 acres. The climate of that section of the Tar Heel State is generally favorable the year round for the outdoor work commonly relied upon in shipbuilding. Wilmington is linked by two trunk lines with the railway network of the nation, and therefore in connection with the hundreds of manufacturing plants that contribute in one

Photos, U. S. Maritime Commission.





"I CHRISTEN THEE - - "

A Liberty Ship all dolled up and ready for her baptismal dip is pictured at the top, left. At the right she is seen sliding down the launching ways. In the center, the "William Hawkins" is being maneuvered to one of the outfitting piers. Cargo vessels of this type have an over-all length of 441.5 feet, a maximum width of 57 feet, and a draft when laden of 27.66 feet. Each has a maximum displacement of 14,100 tons, an estimated dead-weight capacity of 10,500 tons, and a general cargo capacity of 9,146 tons; is driven by a single propeller actuated by a reciprocating steam engine of 2,500 shp.; and has a normal sea speed of from 10 to 11 knots. Since the first Liberty Ship was put on the keel blocks in the yard of North Carolina Shipbuilding Company, the time required to construct one hull has been reduced from an average of 271 to 30.9 days!

INITIAL STAGES

Making ready for the erection of a hull on a shipway by fitting the keel blocks which will bear most of the vessel's weight while she is under construction.

way or another to the building and equipping of Liberty Ships. The region is a fairly populous one, and affords an ample supply of unskilled labor. Ships cannot be constructed, however, by such labor, and it may be of help in evaluating what has been done by North Carolina Shipbuilding Company to point out that 98 per cent of the workers in the yard had to be trained for their jobs.

In transforming the unimproved land into an area that would serve its purposes, the company made use of portable air compressors of a large type that acted as mobile power plants in getting the yard ready for shipbuilding. The enterprise and energy displayed at this stage of the great undertaking was recognized by the Maritime Commission which gave North Carolina Shipbuilding Company on March 14, 1941, while these preparations were underway, a contract for 25 Liberty Ships at an estimated base cost of $37,500,000. All these vessels were to be delivered within 531 days, and the contractor was allowed 287 days from the date of award in which to produce the first of the group.

The company expected to have its plant completed by the first of August of that year and to start keel-laying within four months after signing the contract for the yard. The pressing need for more than the 200 Liberty Ships ordered by the President at the beginning of the construction program caused the Maritime Commission to provide funds for three additional ways—thus augmenting that part of the plant by 50 per cent. And in the first half of April, 1941, North Carolina Shipbuilding Company was awarded a second contract for twelve more Liberty Ships at a base cost of $19,800,000, increasing the number to 37.

On May 22 were laid the keels for two vessels, marking the actual beginning of shipbuilding. On December 6, following, the first of those craft—the *Zebulon B. Vance*—slid into the water. It had taken 198 days to put her together and to launch her, and 73 days to outfit her and to make her ready for sea—a total of 271, or sixteen days sooner than required under the terms of the contract. The newness of the shipyard, the novel building methods adopted, and the fact that the vast majority of the workers had had no previous shipyard experience, afford a basis upon which to evaluate what has since been done at that plant. When 1942 ended, North Carolina Shipbuilding Company had delivered to the Maritime Commission 51 Liberty Ships totaling 549,600 dead-weight tons within a period only 4½ months longer than the time initially allotted for the construction of 25 ships! Succeeding contracts increased to 90 the number of vessels that the yard was to turn out, and by the end of April of this year—in which month ten were delivered—89 of them had been completed.

The accompanying table shows how North Carolina Shipbuilding Company has progressively quickened its pace and lengthened its stride, as typified by the number of ships produced per month and turned over to the Government.

The Liberty Shipyard is notably different from the country's older conventional yards in which it has long been the practice to construct the hulls and also the boilers, propelling machinery, and much of the other equipment and parts. The new shipyard puts together the hulls and assembles and installs in them the boilers, engines, propellers, pumps, cargo-handling machinery, etc., obtained from outside manufacturing concerns. This, in a measure, accounts for the spectacular rapidity with which the foremost of them are building the Liberty Ships. The U.S. Maritime Commission offers the following in further explanation of these amazing performances: "Some of the new methods employed by the shipyards which have contributed to the record-breaking are extensive prefabrication, or the building of large sections of a ship before they are carried to the shipways; the increased use of welding instead of riveting, which conserves manpower and material and provides a stronger ship construction in shorter time; and the adaptation of assembly-line methods to the construction of the ship itself."

Like the other new yards, North Carolina Shipbuilding Company was left free to put the vessels together by riveting or welding. The Newport News Shipbuilding & Dry Dock Company, by reason of its own initiative and by extensive researches conducted by experts of the Navy, had pioneered in welding in ship construction. Accordingly, North Carolina Shipbuilding Company relies upon welding but, where it is deemed more desirable to do so, uses rivets—some 24,000 of them—to bind each hull together.

It has been authoritatively stated that more than 90 per cent of the men and women at present employed in the Liberty Shipyards have had to be trained for the jobs. But even with the training program

	Vessel Number	Days On Ways Average	Days Outfitting Average	Total Building Days—Average
February, 1942	1	198.00	73.00	271.00
March	2	245.50	53.00	298.50
April	3	189.33	40.00	229.33
May	4	186.50	27.50	214.00
June	5	97.40	17.50	114.90
July	5	67.60	16.80	84.40
August	4	57.20	17.00	74.20
September	5	63.80	12.80	76.60
October	6	58.80	10.30	69.10
November	7	44.50	11.40	55.90
December	9	34.70	12.30	47.00
January, 1943	9	32.30	11.30	43.60
February	9	29.00	9.20	38.20
March	10	29.90	7.50	37.40
April	10	29.80	6.90	36.70
May	11	24.40	6.50	30.90

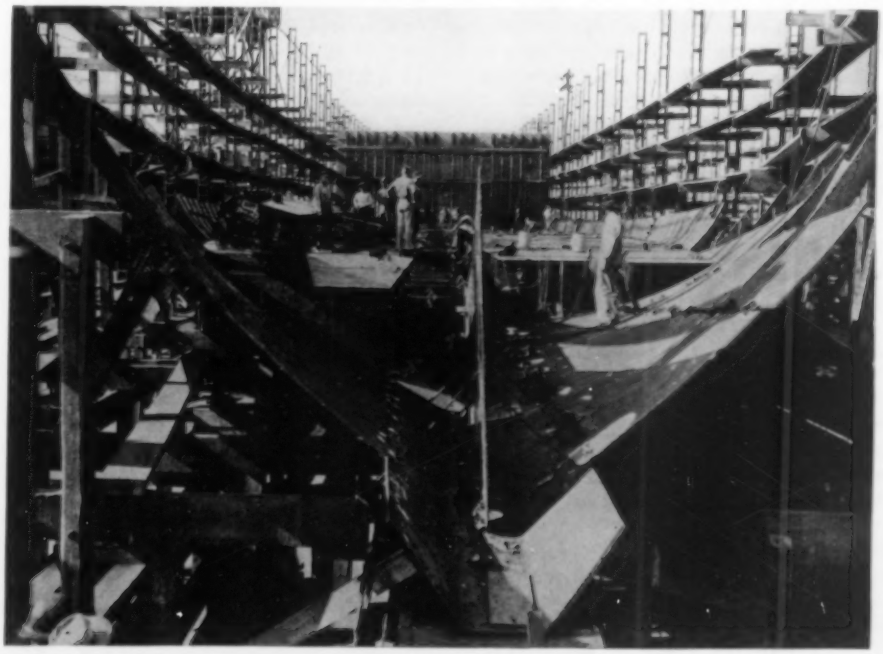
adopted, the work could not have been done had the older methods common to the shipbuilding fraternity been continued. It was essential that the individual job be simplified to enable each worker to attain the necessary skill in the shortest possible time. North Carolina Shipbuilding Company has been conspicuously successful in this direction.

Along the waterfront and immediately downstream from the nine shipways are the three long outfitting piers where the vessels, after launching, are moored while they receive their finishing touches, undergo dock trials, and otherwise are made ready for delivery to the Maritime Commission. The ways and outfitting piers are the focal points towards which all other activities in the yard are directed. The property upstream from the shipways is mainly devoted to the storage of raw materials and to the various divisions of the fabricating plant, where work is done in the open and in shops equipped for the purpose. The remainder of the yard is given over to assembling, erecting, and outfitting—the nearer the preparatory work approaches completion, the closer it is to the shipways or outfitting piers.

The conspicuous aspect of the layout is the amount of operating elbow room provided. The yard now has a working force of about 20,000 men and women—mostly men; and where a few hundred would ordinarily be employed on a shipway in an older yard, a much greater number can be kept busy in this one without interfering with one another. Because of this, the parts and sections of six vessels are fabricated and assembled simultaneously so that they can be moved to storage areas near the shipways or transported directly to the latter and lowered by great cranes into their assigned positions in constructing a hull. This saves time that otherwise would be lost in changing or shifting tools for different operations on first one and then another vessel.

Actual erection starts with the laying of the flat keel plates on the keel blocks of the shipway and then welding them together at their transverse joints or butts to form what might be called the spine of the craft. The laying of the keel plates is begun at midlength of the vessel and proceeds forward and aft to the bow and stern, respectively—the order of welding them together following in the same sequence. The remainder of the bottom plating extends outward from the keel plates to the line where the hull turns upward at the bilges and merges into the vertical sides of the outer body or shell of the ship. To expedite operations, the bottom plating on each side of the keel is put together on shore while resting on skids that hold the plates about 4 feet above ground so that welders can work "overhead" when filling the nether groove of a butt or a seam. Work on the upper groove is done by machine, which places the bead quickly and automatically under electric control and can be regulated for each job. Before the butts and then the seams are machine welded, the welding metal deposited from the underside is calked with pneumatic hammers fitted with a sharp tool. Next the grooves are either blown clean with compressed air or swept clear with hand-wielded wire brushes—whichever is most effective. The expansive assembly of A, B, and C strakes is now cut into unit lengths with oxy-propane cutting machines, picked up by a crane, and lowered into position on one or the other side of the keel plates, to which they are joined by manually welding the underside of the junction seam and machine welding the upper groove of the seam after it has been calked, as previously described. The bottom plates are held in place by supporting frames and are temporarily tied to the keel plates by short pieces of metal that span the longitudinal seams and that are spot welded to the plates to be united. The dogs can be quickly detached with an oxy-propane torch. Bottom-plate laying starts amidships, and continues forward and aft—the work proceeding symmetrically on each side of the keel.

The side plating throughout a hull's midlength where the shell rises straight up from the bilge is assembled on low skids on which are laid the ribs or frames of the hull to which the plates are riveted after they have been tied together by welding into a number of longitudinal panels. The steel frames are secured to the skids before the shell plating is placed upon the frames and temporarily bolted to them through holes drilled and countersunk with pneumatic drills. The plate edges are brought together snugly preparatory to bolting and are beveled in advance in the fabricating shop or on a platen—a platform of heavy plates perforated at frequent intervals to facilitate runoff of water during rainfall. The upper or outside edges of contiguous plates are beveled at a 45° included angle while those on the underside, the one that will be inside the ship, are beveled to form a 60° included angle. The undergroove in either a butt or a seam is welded manually by depositing an overhead bead. The top groove is downwelded by machine after the nether bead has been calked with pneumatic hammers and cleaned of any loose material, as previously mentioned. In all cases, the butts or transverse grooves are welded first, and then the longitudinal grooves. This procedure is followed so that the stresses set up by the heat, which causes expansion followed by contraction due to chilling, may have a chance to relieve the tension caused by the "growing pains" of the evolving structure. When all movement in the plating due to the welding reactions has ceased, then, and then only, are the plates riveted to the underlying frames. But before this is done, the assembled plating is cut by oxy-propane machines into 3-strake panels ranging in length from 20 to 30 feet and averaging 14 tons in weight. These panels form the shell plating from



EARLY STAGES OF CONSTRUCTION

A Liberty Ship looking from one of the forward sections of the hull towards the first of her bulkheads erected near midlength. The picture shows her bottom plating with some of the double-bottom structure in place. Most of the workmen are standing on the tank top. The outside plating with supporting ribs attached will rise above the upper level of the bottom plating, which can be seen projecting upward from the tank top.

HULL NEARING COMPLETION

Looking forward toward the inshore end of a Liberty Ship in an advanced stage of construction. Note the great cranes with their long reach that move between the shipways and handle the heavy loads. As many as three are required in maneuvering and lowering into exact position the lower section of the bow, which is assembled on shore and weighs 47 tons. It is the heaviest of all the sections handled in building a hull.

the bilge up to a point a little above the ship's load line. Similar panels complete the shell plating, in two strakes, up to the main or weather deck.

The side plating is not erected until the double-bottom sections have been assembled on shore, ready to be lowered into their respective places upon the bottom-shell plating. When snugly in contact, the double-bottom structure and the bottom plates are joined by welding—that work being done by hand. A Liberty Ship requires eighteen double-bottom sections, each extending the full width of the vessel and ranging in length (along keel) from 9 to 27 feet. The heaviest of them weighs approximately 41 tons. These units are prefabricated and assembled on platens in the yard. The plates that form the tank top are laid on the platen upside down and welded by machine. Then the transverse members, the central vertical keel which supports the tank top when in position in the ship, and certain other structural members are tied together by continuous, manually laid fillet welds. While still upside down, as much as possible of the double-bottom piping is put in place, for it would be a time-consuming job to carry it through later. Next, the subassembly is turned over and the yet-unsealed seams and butts of the tank-top plating are finish-welded by machine. The transverse joints of contiguous double-bottom sections are machine welded at the tank top.

The first five of the inner bottom sections are placed in a hull amidships, after which are erected the first of the watertight bulkheads that extend from the double bottom up to the lower deck. These bulkheads, the heaviest of which weighs about 24 tons, form the longitudinal boundaries of the vessel's boiler and engine spaces. All main bulkheads are prefabricated and assembled on platens in a large fabricating shop inshore from Shipway No. 1. The lighter 'tween-deck bulkheads also are prefabricated on platens. None of the side-shell plating is erected on a shipway until the bulkheads to which they are to be secured have been placed in the hull structure.

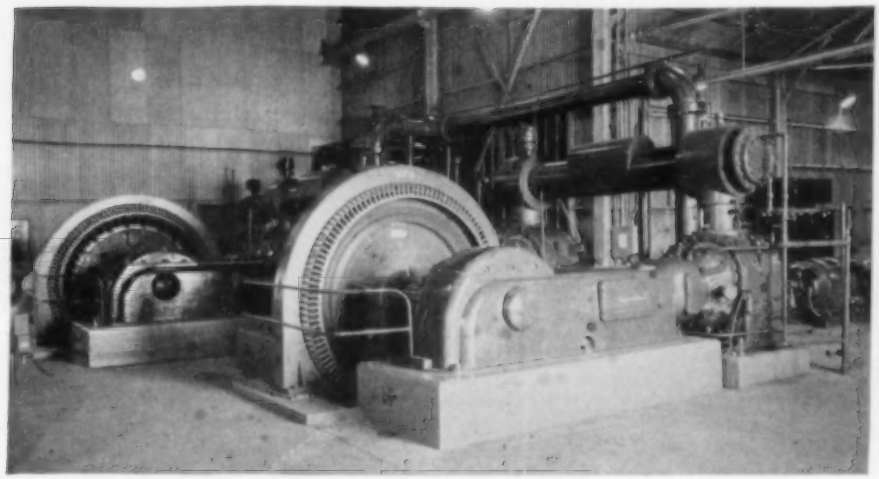
Beyond the straight midlength body of a Liberty Ship to the bow and the stern, respectively, the form of the vessel changes continuously. The plating for the lower sides is subassembled in the shipyard upon special cradles that are modeled so that they will hold, in slotted recesses, the previously shaped steel frames that subscribe to the lines of the molded form of the vessel. Because the surfaces are curved and do not permit welding by machine, the butts and seams are manually welded on the outboard surface of the assembly. With that done, and when all "creep" due to welding reactions has ceased, the plating is riveted to the frames ready for erection in the hull. Chipping hammers or pneumatic calkers prepare the root bead, laid on the underside, for the final welding. This is also done manually, but downhand instead of overhead as in the case of the root bead.

The bow and stern assemblies, which are somewhat complex structures, are put together on the ground in the shipyard and temporarily bolted together while the shell plating is being welded. With that work finished, the plating is riveted to the frames. Because the bow structure is too heavy for handling as a unit it is assembled in two sections—upper and lower. Even so, the lower one alone weighs about 47 tons. The stern is likewise put together on the ground in two sections—the main body and the lighter aftermost section. The latter extends beyond the heavy frame which forms a part of the main stern structure.

For drilling holes for the numerous

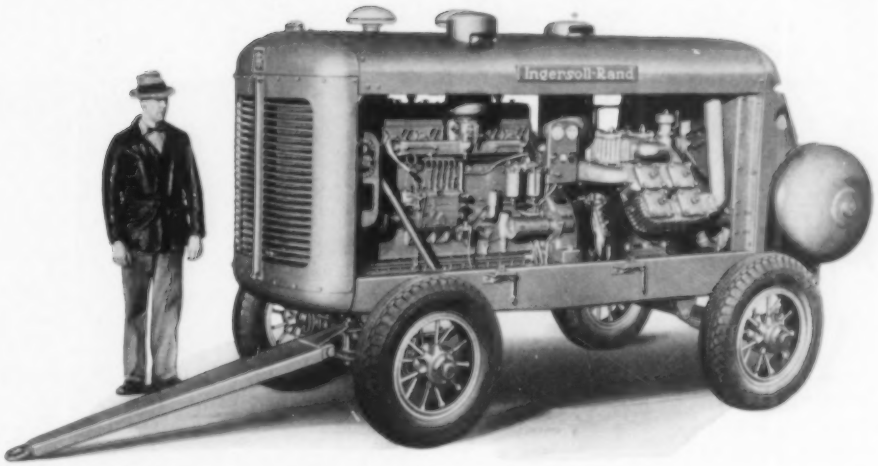
ALL THAT HOLDS HER

The final tie that binds a ship to her building ways is the steel plate shown here. The operator is in the act of severing the plate to release the vessel so she can slide down the launching ways.



SOURCES OF COMPRESSED AIR

At the left is an interior view of Power House No. 1 showing two of the three PRE-2 compressors installed there. They have a rated capacity of 3,400 cfm. each and deliver air to the distribution system at a pressure of 100 pounds. Power House No. 2 houses a single machine with a capacity of 4,435 cfm. Below is pictured a portable compressor of the type used about the yard, shipways, and even on board the hulls—in the latter case to operate winches to help warp the vessels to outfitting docks. The unit has a capacity of 500 cfm.



rivets in each hull and for other purposes, and also for reaming, the shipyard has in use 583 pneumatic drills, while riveting is done with 121 air-driven rivet hammers. For chipping root beads to sound metal before the finishing welding metal is laid by machine, as well as for truing plate edges to assure a nice fit, the plant has in service nearly 1,170 chipping hammers. There are 841 pneumatic grinders available for a diversity of fitting and finishing operations; 262 pneumatic vane wrenches deal with the bolts used during the subassembly work; and eight saws are included among the yard's air-driven equipment.

Compressed air is utilized for many other purposes. For example, most of the painting is done by air-spraying; and compressed air has numerous applications in the machine shop, the boiler-assembly shop, and elsewhere throughout the yard—air lines transmitting the energy to every section of the widespread plant. The main sources of supply are Power Plants Nos. 1 and 2 in the southern and northern sections of the yard, respectively. No. 1 contains three Ingersoll-Rand PRE-2 compressors, each with a rated capacity of 3,400 cfm. They deliver air to the distributing system at a pressure of 100 pounds per square inch. Power House No. 2 has a single machine of 4,435 cfm. capacity. This arrangement provides a reserve, lends itself to a well-balanced distribution of the air, and places the 3-unit installation near the zone of heaviest demand. The machines are driven by General Electric, 800-hp. synchronous motors that operate at 150 rpm. Motive current is supplied the shipyard by the Tidewater Power Company.

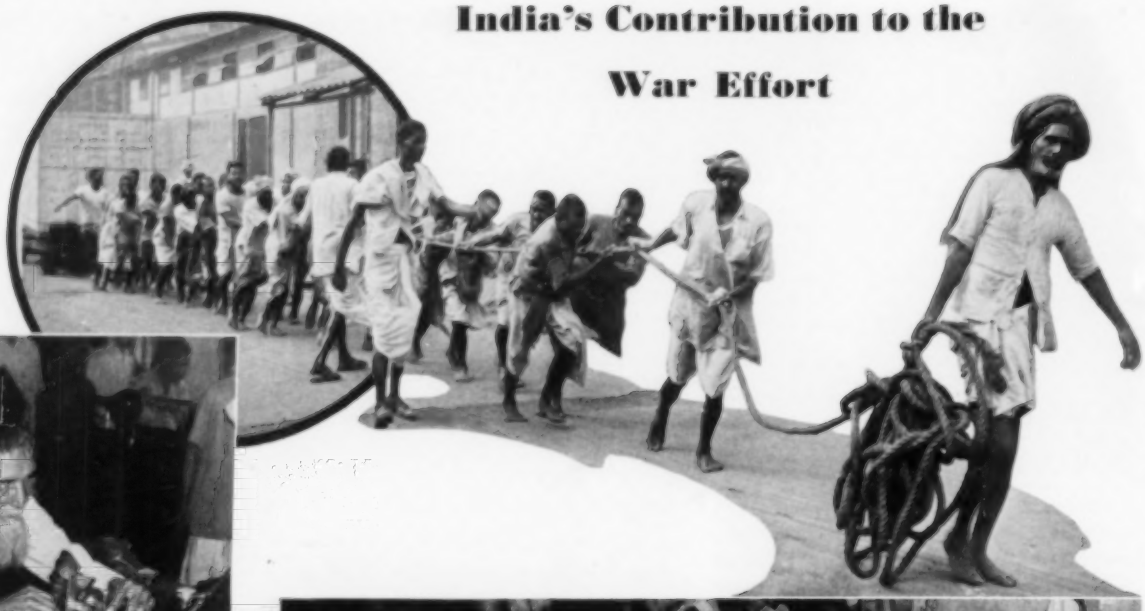
In addition to the foregoing compressors the shipyard has two large portables of the Ingersoll-Rand K-500 Type. These machines have proved their value by the way in which they can be adapted to varied emergency services. In some yards there is a small compressor at each shipway that calls for the employment of three men per day to meet the possible requirements of three working shifts, as the building of Liberty Ships goes forward seven days a week and 24 hours a day. The two portables at the yard of North Carolina Shipbuilding Company can be moved anywhere to meet occasional demands. For instance, one furnishes compressed air at each shipway for a steam winch when the latter is used to pull the sliding ways into place in making ready for a launching. The other K-500 is hoisted aboard the vessel shortly before she is put overboard to supply air to drive the cargo winches that help to warp her to the outfitting pier immediately following her launching—no steam being available on the ship at that time. The same portable also provides air to operate calking hammers to close any small leaks that may be discovered when the craft is first put in the water.

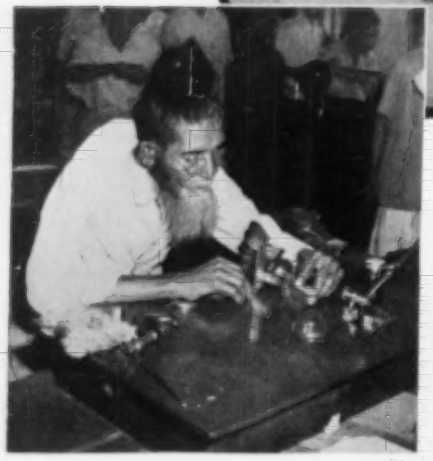
At each shipway, at longitudinal intervals of 50 feet on each side, are air-line risers with manifolds at every working level to provide air for operations during erection. The idea of this multiple arrangement is to make it possible to limit the unit length of each stretch of air hose to 100 feet. Air lines are likewise led to each of the platens, fabricating skids, and to all the shops. Indeed, compressed air in this yard seems to be just as important and its use quite as widespread as it is in the older order of shipbuilding plants.

Apart from the directive skill in evidence in the yard of North Carolina Shipbuilding Company, and the enthusiasm and energy manifested by the workers, no small part of the speed of output and the excellence of the work done, as proved by sea-going service, may be attributed to the gradually evolved "sequence of erection" which is intended to reduce construction difficulties and to minimize the residual stresses developed during assembly and subsequent erection on the ways. Changes are made from time to time in the schedule whenever betterment appears possible, and this accounts in large part for the company's substantial contribution towards the effort to win the war.

The officers of North Carolina Shipbuilding Company are: Homer L. Ferguson, chairman of the board; Capt. Roger Williams, president; P. F. Halsey, vice-president and general manager; Robert I. Fletcher, comptroller; W. Graham Scott, treasurer; Storer P. Ware, secretary and assistant treasurer; T. L. Lanier, assistant comptroller; Paul A. Wilson, assistant treasurer; and Kemper L. Kellogg, assistant secretary.

India's Contribution to the War Effort





Photos, Office of War Information

INDUSTRIAL INDIA

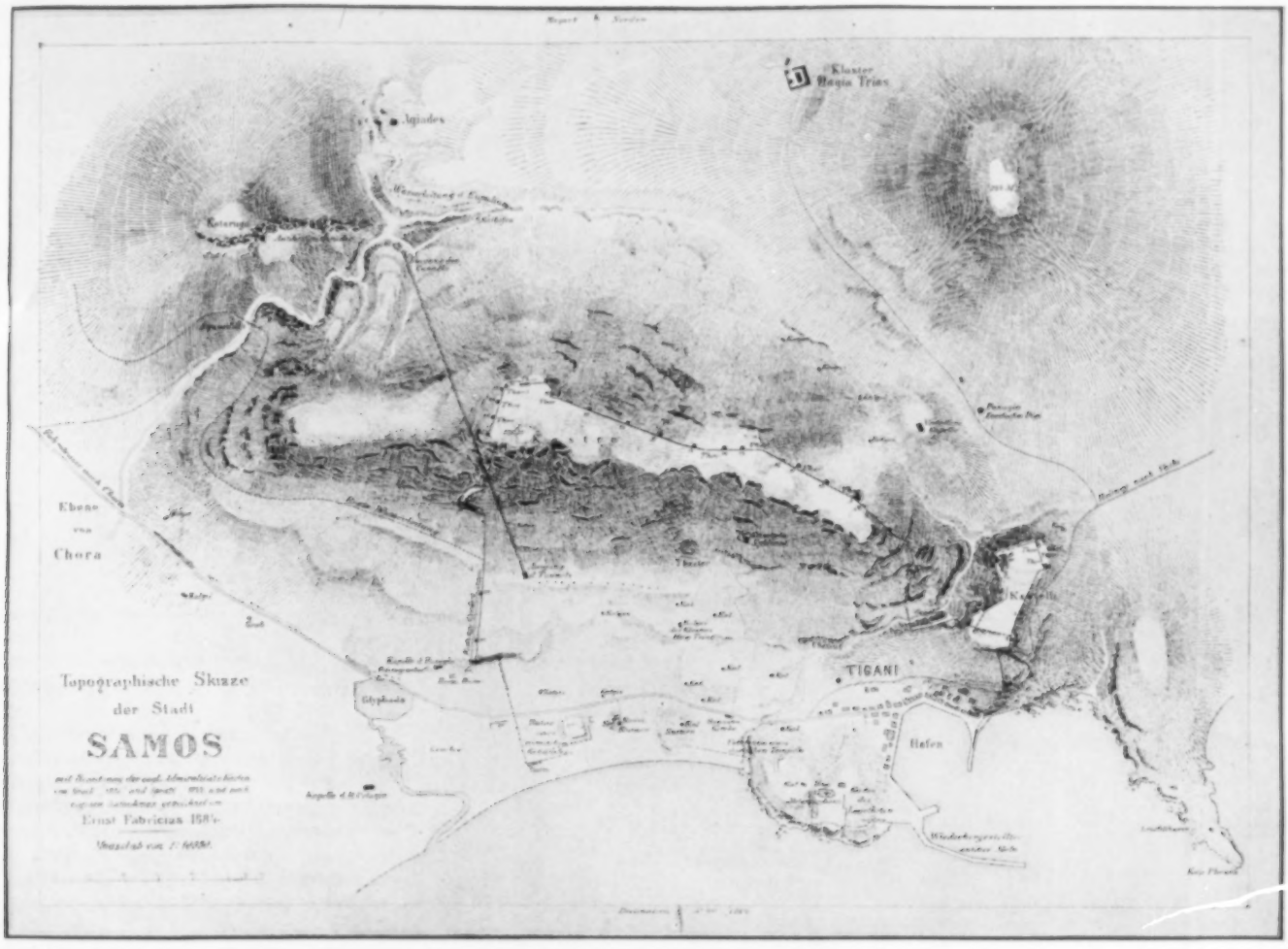
At the left is 62-year-old Ellahi Bukhsh, an expert gauge fitter, whose father worked in the same plant and some of whose children are also employed there. The picture at the top shows a newly arrived crate containing a hydraulic lathe made in St. Louis, Mo. It was hauled into a munitions factory by 35 Bengali laborers who chanted in unison as they tugged away at the rope. The equipment materially increased the plant's monthly output of cannon. The workers seen directly above are putting the finishing touches on shells. Trained men and new machinery stepped up the production of this factory 24 times, as compared with prewar figures.

A FACT not generally known—one that may astonish a great many people—is that even before the war India was preëminent as an industrial country. Most of us, accustomed to the whirring machines and the assembly-line methods of American industry, do not think of India in terms of mass production. We are inclined to think of her as a land of adventure and mysticism, of ancient temples, of queer, exotic customs—in short, as a novelist's paradise. Yet it has been said on good authority that, in industrial matters, India stood eighth among the nations of the world during the years immediately preceding the conflict.

In view of this fact, her present output of vital war materials is perhaps not surprising. With the aid of new equipment—much of it supplied by the United States under the lend-lease arrangement—India is today producing as much ammunition in a month as she did in a year prior to the outbreak of hostilities. She is turning out eight times as many guns and 24 times as many shells as she produced before the war, and these figures are mounting steadily.

True, in some respects, India remains the India of old. There are still plants in which native workmen labor at obsolete machines, but in many of them the equipment is being improved rapidly. Toiling in a hodge-podge of antiquated and new machinery are Indian workers of all ages. Some of them, now approaching old age, have sons and grandsons at benches near by. Ellahi Bukhsh, a bearded, 62-year-old Moslem, is typical. An expert gauge fitter who can work to 0.0002 of an inch, he boasts nearly 30 years' service in a single factory. He has six children, some of whom are employed in the same plant, the others in neighboring ones engaged in war production. Though not an educated man, he has definite views on the meaning of lend-lease assistance. "It means much to India," he says, "because it gives our young men a chance to be trained with modern machines." Maj. T. F. Borick, Director of Ordnance Factories, credits much of the country's recent industrial expansion to new equipment, and the records of various plants indicate that efficiency and output are high where it is in use.

An example of Indian industry is a factory described as the world's oldest precision-instrument plant. There are found American drilling machines and jig borers, sawing and filing equipment, broaching and milling machines, and lathes, as well as tools, tool steel, glass, Carborundum, bort (industrial diamonds) for glass-cutting, and rouge for glass-finishing. The factory produces surveyors' equipment, range finders, clinometers, stereoscopes for the artillery and air forces, glass tubing, rules and angles for navigational purposes, and thermometers of all kinds, particularly the delicate type used in the manufacture of explosives. In this plant, as in others, the management follows the practice of training selected Indian labor and encouraging the sons of the workmen to follow in the footsteps of their fathers, a policy that has helped to develop not only a capable but also a loyal personnel.



SAMOS AND THE TUNNEL OF EUPALINOS

The tunnel, believed to have been one of the first of its kind ever driven, is shown as an angling line crossing down through the left-central portion of the map. A conduit starts at the point marked Agiades (upper left), runs downward for a distance, then to the right around an elevation, and back to the left to enter the tunnel. Its course can be traced by a series of dots, representing pits in the ground that were connected. The map, which was drawn by Ernst Fabricius, who conducted investigations at the site in 1884, also shows the walls of the city and the mole, which was among the earliest of outstanding engineering works.

Eupalinos — First Civil Engineer

F. Russell Bichowsky

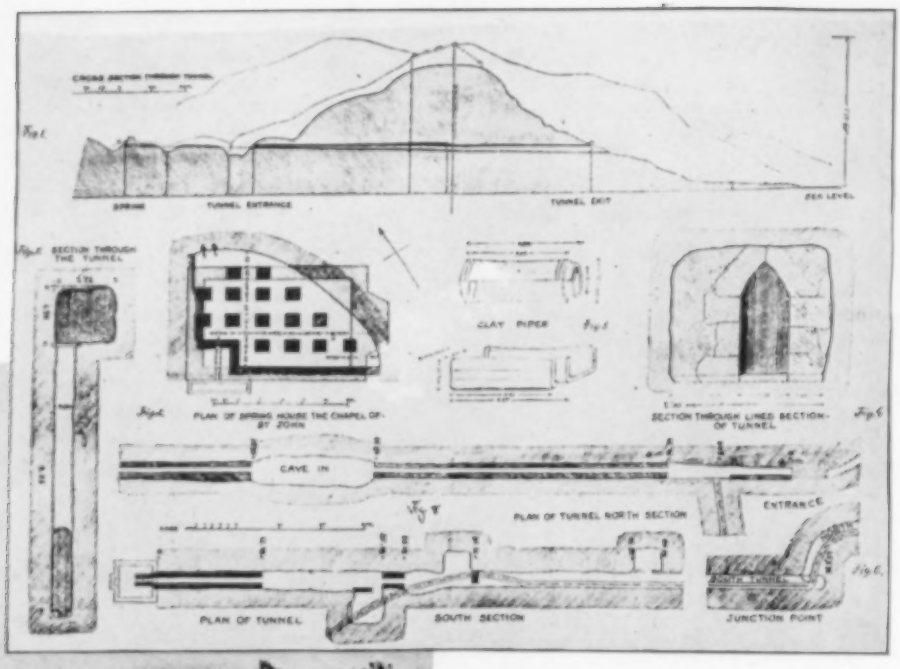
"I HAVE written thus at length of the Samians," stated Herodotus the Greek historian about 450 B.C., "because they are the makers of the three greatest works to be seen in any Greek land. First of these is a double-mouthed channel pierced through the base of a hill a hundred and fifty fathoms high. The channel is seven furlongs long, eight feet high and eight feet wide; and throughout the whole of its length there runs another channel twenty cubits deep (30 feet) and three feet wide, wherethrough the water coming from an abundant spring is carried by its pipes to the city of Samos. The designer of this work was Eupalinos, son of Naustrophos, a Megarian." There is another passage which probably refers to Eupalinos, as follows: "Polycrates (properly Aieces, tyrant of Samos from 565 to 540 B.C.) also encouraged . . . . . the immigration of artizans at very high wages." These are the only mentions in ancient literature to the man who was probably the world's first civil engineer, but much more can be learned about him from the study of the remains of his works.

In 1855 the French traveler Victor Guerin spent some time on Samos, a little island lying less than a mile off the coast of Asia Minor and not far from the city of Smyrna. There he made the discovery that the modern Chapel of St. John the Baptist (marked Agiades on the map) was built over an ancient reservoir which he recognized as the one fed by the "abundant spring" of Herodotus's account. He also located the beginning of the conduit and was able to trace it a short distance; but he did not find the tunnel proper.

In 1882, Cyril, abbot of the Monastery of the Holy Trinity, (Hagia Trias), while cultivating land on the south slope of Castro Hill, came across the remains of an ancient conduit which, when laboriously followed back, led to the tunnel of Eupalinos. Since the latter seemed to be in surprisingly good condition, he conceived the idea that it might be restored to its original usefulness. Obtaining the support of the governor, he located and cleaned out the section of the conduit from the source at the spring to the north end of the tunnel and about half of the tunnel itself. At this point, the funds gave out. Shortly afterwards, the German Archaeological Institute at Athens sent one of

SAMOS AND TUNNEL DETAILS

Below is the city of Samos looking towards the harbor, showing the rebuilt mole. The tunnel was evidently built not only to supply water but also to provide a secret means of escape from the city in case it was overpowered by besiegers. It was apparently dug through the limestone formation with hand picks, and it is believed that daily progress was not more than 6 inches at each end.



its members, Ernst Fabricius, to Samos to study the work. Apparently, the investigation was rather hurried, for the published article on the subject does not furnish the data necessary to date the tunnel and fails to mention many engineering details that would be of the greatest importance to the history of engineering. Nevertheless, it is complete enough to show that the tunnel well deserved Herodotus's encomium.

Starting at the reservoir of St. John, which in ancient times was hidden under the floor of a small temple, the water passed through a small settling basin to an underground conduit constructed much like a modern sewer with pits and short connecting tunnels. The spacing of the pits varies and ranges from 70 to 260 feet, while the short connections are generally about 6x2 feet in section. Some of the latter are lined, others have a reinforced roof. Because of the irregularities of the land the pits differ in construction and depth, one near the tunnel mouth being 47 feet deep. Usually they are oval in form, 4½x3 feet being typical. When found they were covered and well concealed. There was only one adit that was open, presumably to allow air to enter, but this was ingeniously hidden in the rocks.

The route of this conduit is shown on the map by a line of black dots, which indicate the position of the pits. As will be seen, it conforms to a contour, proceeding in a tortuous course around the head of two small valleys. It has a total length of 2,800 feet, a maximum depth of about 50 feet, and, where it crossed the larger stream, a minimum depth of approximately 10 feet.

In the bottom of this conduit was found, partially intact, a pipeline made of clay pipes very much like those of modern sewers. These are of two sizes, differing only in length and in the quality of the clay. The longer ones were about 2 feet in length, had an internal diameter of 7 inches, and walls approximately ¾ inch thick. They were provided with bell-and-tongue ends and were evidently made on a potter's wheel. Every other pipe in the run had an air vent in the upper surface for the purpose, no doubt, of preventing the line from being put under suction. The joints were luted with a white mixture that was probably composed of lime and castor oil.

The conduit, with its pipeline, enters the main tunnel at right angles at a point about 30 feet in from the north portal. This is well hidden, as indeed are all the works outside the city walls. Obviously, it was essential to conceal their existence from a besieging army, for otherwise the enemy might have cut off the water supply or even marched through the tunnel into the city.

The tunnel itself is very much as described by Herodotus. It is 3,300 feet long, and the original bore was 8x8 feet in cross section. It follows a straight course and was excavated from both ends, the junction point being 1,400 feet in from the south portal. There is proof of this in the fact that the two sections did not meet there either as to line or level. The section advanced from the north was found to be about 20 feet west of the one driven from the south, while the floor of the latter was approximately 11 feet below that of the northern end. Connection was made by a section of about the same width as the tunnel proper. This takes off from a point about 5 feet back of the terminus of the south bore, curving westward and upward on an easy grade. Where the connecting section joins the northern end, the tunnel is some 16 feet high. The floor throughout the bore is well finished and was evidently intended for use as a roadway, for otherwise there would have been no need of making the link as wide as the tunnel or of grading it so carefully.

Evidently, some time after construction, cave-ins occurred at various places. In some of these the debris was simply cleaned out, leaving enlarged and irregular cross sections. At other points the tunnel was lined, especially near the entrances, resulting in a reduction in cross section to less than 3 feet and in height to less than 7 feet. Apparently, lining was done at different periods, some as late as the Roman Empire, as indicated by the vaulted roof. The earliest work of this nature seems to date from the third or fourth century B.C., as shown by the carefully built lean-to roof making a well-formed almost Gothic arch. At various places in the tunnel walls are chambers

the purpose of which is problematical. However, they may have been used as tool sheds or assembly points. One, at least, may have served as a chapel, as the broken shaft of a round column would seem to indicate. The bore is essentially level, no allowance having been made for drop necessary for the proper flow of water.

The pipeline, as has been said, enters the tunnel 30 feet in from the north entrance and at a level 8 feet below the tunnel floor. There the pipes give way to open rectilinear troughs, which are carried through the bore in a separate conduit consisting partly of a variously covered trench and of pits with connecting lines. Generally, the conduit extends along and close to the east wall, but in places it is actually underneath it. Not far from the south end it wanders across and runs near the west wall, leaving the tunnel at a point 150 feet in from the south portal. There a small, inclined adit leads out of the mountain, reaching the surface about 100 feet to the east of the tunnel exit. Where the adit and the main bore meet, the conduit is about 30 feet below the tunnel floor, the total drop being approximately 20 feet in 3,000. However, Fabricius was not able to take levels. Parts of the trench and pits are covered with rock slabs and are inaccessible. Elsewhere there is evidence that wooden flooring was used. Some sections of the trench were roofed near the bottom and filled in level with the tunnel floor. Niches in the tunnel walls clearly were cut for lighting purposes, as lamps have been found in them. Unfortunately Fabricius does not picture these lamps, and we therefore lack a very essential clue as to the date of the project.

Tunneling was evidently done by means of hammers and picks—and it is not unreasonable to suppose that drawings found on the base of a column in Samos show the type of tools used. Pick marks are clearly seen in parts of the bore, but no investigation seems to have been made as to whether wedges were utilized, though it is likely that they were. Fire unquestionably was not resorted to, for the ventilation difficulties must have been great enough without it. It may be estimated, or rather guessed, that a period of fifteen years was needed to complete the entire work—ten for the tunnel proper, 6 inches a day at each face. The rock is described as a hard, somewhat bedded limestone.

After leaving the tunnel, the conduit runs easterly and follows a contour for more than 1,000 feet. From there on all traces of it are lost. This section is of the same tunnel-and-pit construction as the one north of the mountain. Only in the former case the pits have removable manhole covers and there are remains in one of a steep stairway giving access to the pipeline. At several points small branches take off, undoubtedly to provide the western part of the city with water. From the point where the conduit is lost to its probable terminus in the city—the public spring house or fountain—is a distance of almost a mile. That the latter has not been located is unfortunate, because its structural details would have given important clues that might have made identification of Eupalinos with other works more certain and permitted more accurate dating than is now possible.

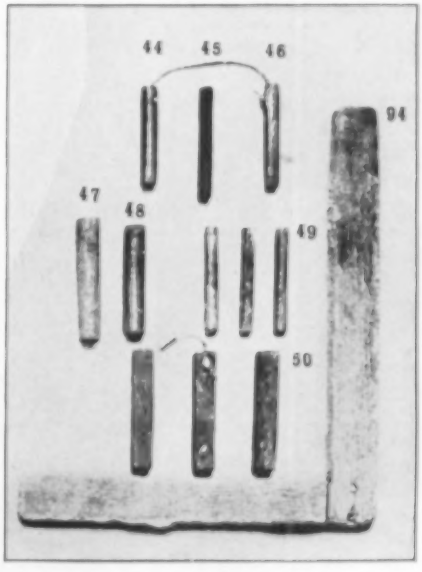
To the engineer, the tunnel presents various interesting angles. The first is its purpose. After leaving the reservoir, the conduit, as has already been mentioned, follows a contour for ½ mile and is in the form of a series of pits and connecting tunnels. These are 2x5½ feet in cross section, hardly big enough to allow a man to work. Then it turns abruptly into the mountain and continues as a separate structure, subordinate to the 8x8-foot or much larger tunnel. This was not necessary, for the stream which the conduit follows partway cuts through the hill at the place in question, and it would have been entirely feasible to proceed by contour all the way to the city. The distance by this route would have been only about twice the length of the tunnel. From an engineering point of view the latter plan would have been preferable and much cheaper.

"Why was a tunnel chosen?" Various authors who have written about the project have given no satisfactory answer to this question. However, it is possible that the tunnel was originally intended both as an aqueduct and as an escape port. Samos was a fortified, walled city. Its people, during the sixth century before Christ and continuing through the Middle Ages, were little better than pirates. Their philosophy was summed up in the following words about Polycrates:

"He harried all men alike, making no difference, for he would get more thanks if he gave a friend back what he had taken than if he never took it at all."

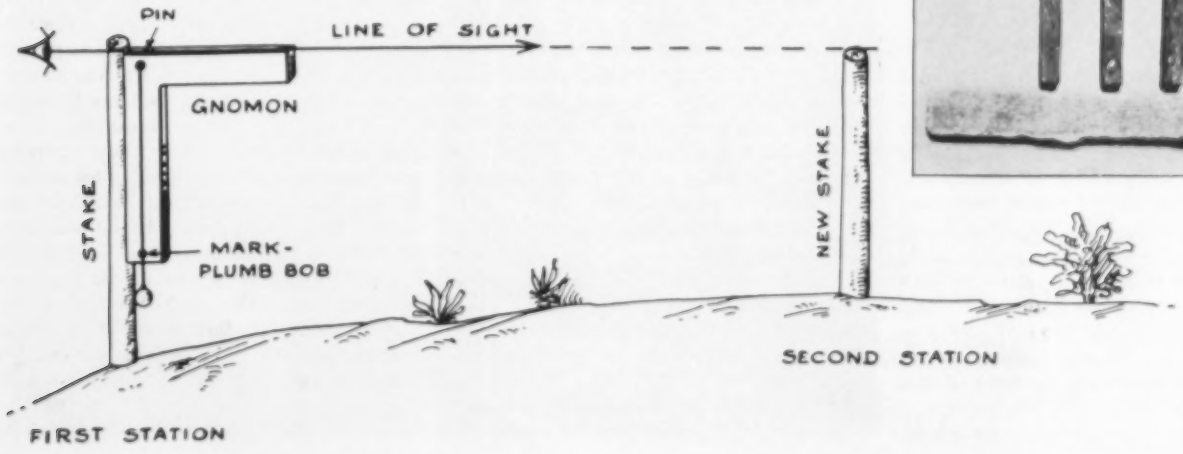
Naturally, they were involved in a series of wars and had to stand siege after siege. The following passage in Herodotus suggests that they may have used the tunnel as a sally port during the siege of 522 B.C.:

"The foreign soldiers and many of the



THE GNOMON AND ITS USE

The gnomon or tee square was introduced into Greece from Babylon by Thales around 565 B.C. It is considered probable that he and his assistant, Anaximandros, were hired as consultants on the tunnel work at Samos, which was only 30 miles from Thales's home. At the right are shown an Egyptian gnomon and surveyor's stakes. The picture below illustrates the use of the gnomon in running a level. It could also be employed as a transit.



Samians sallied down from behind the upper citadel near the ridge of the mountain...."

Somewhat later, in 519 B.C., after the Persians had seized Polycrates by trickery and put him to death, his steward Maeandrius became the reluctant ruler of the island. To again quote Herodotus:

"So when the Persians brought Syloson back to Samos, none resisted them, but Maeandrius and those of his faction offered to depart from the island under a flag of truce; Otanes agreed to this, and the treaty being made, the Persians of highest rank sat them down on seats that they had set over against the citadel.

"Now Maeandrius the despot had a crazy brother named Charilaus, who lay bound in the dungeon for some offense; this man heard what was afoot, and by peering through the dungeon window saw the Persians sitting there peaceably; whereupon he cried with a loud voice that he desired to have speech with Maeandrius. His brother, hearing him, bade Charilaus be loosed and brought before him. No sooner had he been brought than he essayed with much reviling and abuse to persuade Maeandrius to attack the Persians. 'Villain,' he cried, 'you have bound and imprisoned me, your own brother, who has done nothing to deserve it; and when you see the Persians casting you out of house and home, have you no courage to avenge yourself though you could so easily master them? If you are yourself afraid of them, give me your foreign guards, and I will punish them for their coming hither; as for you, I will give you safe conduct out of the island.'

"So said Charilaus. Maeandrius took his advice . . . . . for he knew that he could get himself safe out of the island whenever he would, having made a secret passage leading from the citadel to the sea. Maeandrius then set sail himself from Samos; but Charilaus armed all the guards, opened the citadel gates, and threw the guard upon the Persians."

At any event, the tunnel was an ideal means of escape in those ancient days, for not only was its northern portal in a hidden valley but there was also good communication between the latter and the rugged, little-used north shore of the island.

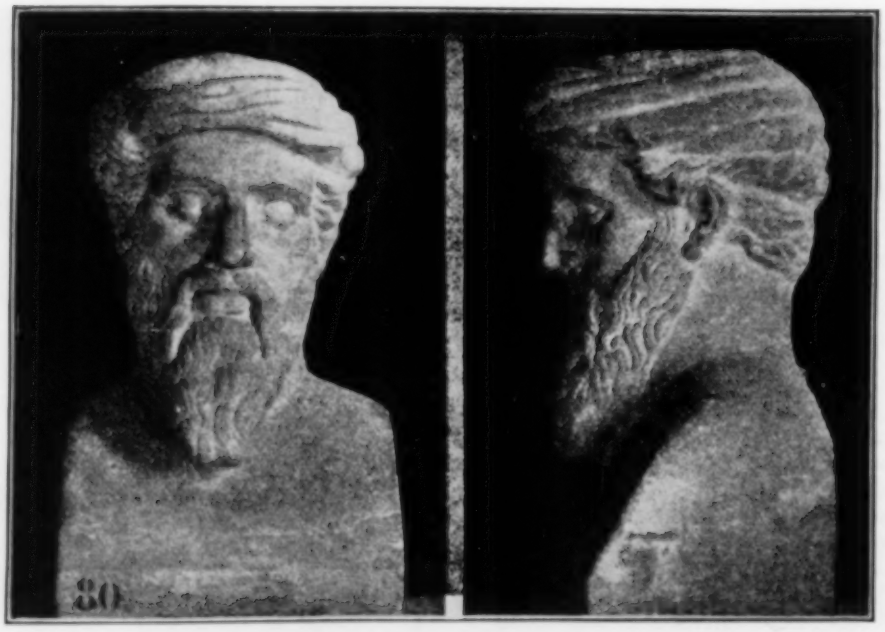
The next matter of interest to the civil engineer is how the surveying was done. The tunnel was cut straight through the mountain from both ends and met with relatively fair accuracy. Evidently, some sort of level-and-transit system was used. To determine what this was, we must date the tunnel. Herodotus saw it around 460 B.C., and it could not have been surveyed before 590 B.C. Before that time no Greek had knowledge of geometry or surveying necessary for the job. It was during the period 590–460 B.C. that geometry was born and made surprising progress. Hence, accurate dating of the tunnel is a matter of some importance to the history of both geometry and engineering.

Fortunately, the tunnel can be dated with some reliability. It must have been completed before the siege of 525 B.C., for a city of 50,000 could hardly have successfully sustained a 40-day siege without water. That means it must have been begun before 540 B.C., assuming fifteen years as the time of construction. This brings its starting date within the reign or Aieces, tyrant of Samos, sometimes confused with Polycrates, his famous son. Aieces' rule began about 565 B.C. Unsettled political conditions before his reign would seem to render the years 590–565 B.C. impossible. The most probable period is therefore 565–540 B.C.

This is confirming evidence that the builder of the tunnel was Eupalinos of Megara, a small city near Athens, across the Aegean Sea. The most plausible reason for hiring an engineer from Megara is that he was experienced in the construction of water works. There has been found in Megara a municipal water system, the first of its kind known anywhere in Greece, which brought water by pipeline for half a mile or so from the Sithnid Spring to the fountain house of Theagenes. This line was built of open-topped clay pipes and of square-sided clay troughs similar to those used in Samos. The system has not been fully excavated, thus leaving the structural features of the conduit undetermined. Furthermore, inasmuch as the spring house at Samos has not been found, it is impossible to compare it with that at Megara. But the coincidence of locations and the similarity of the pipes and troughs seem to indicate that Eupalinos was associated with the Megara spring house.

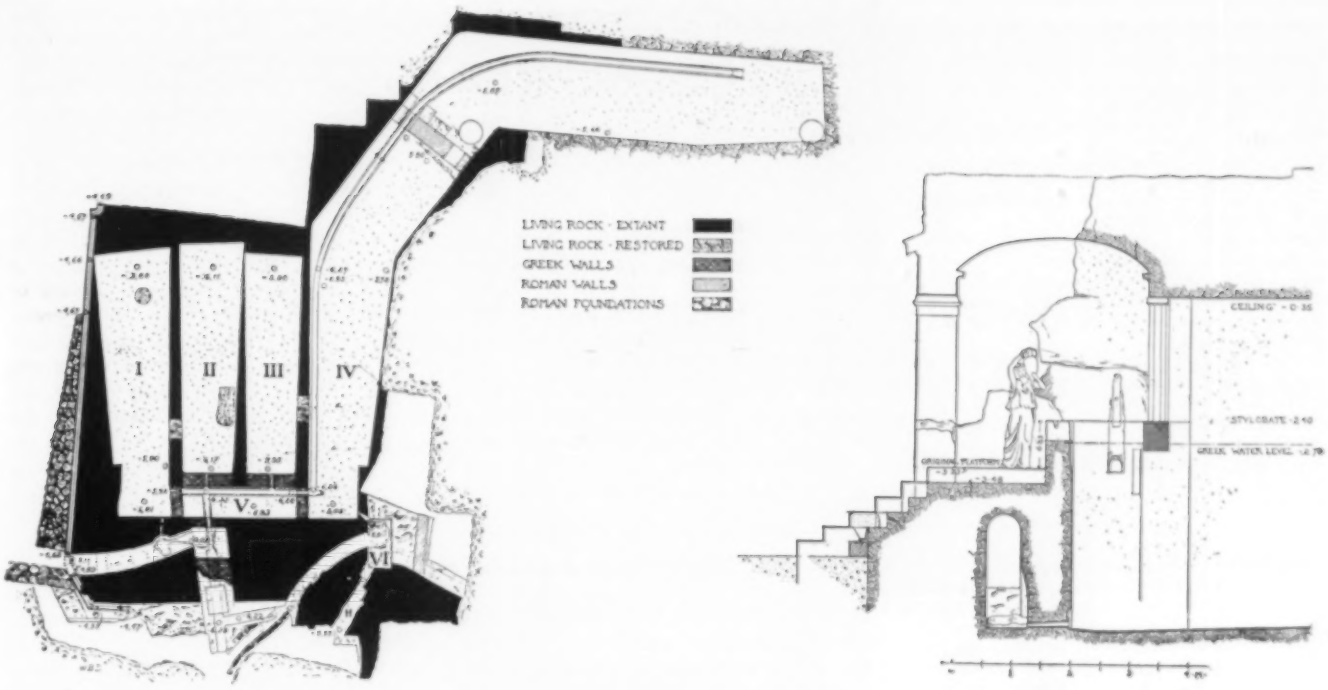
The Megara fountain can be accurately dated. It must have been begun not later than 600 B.C., for Theagenes, tyrant of Megara after whom the structure was named, died during that year. It must have been finished by 590 B.C., as the stable government of Megara was overthrown at that time. If Eupalinos had been 30 years old when he worked on the Megara fountain, and if that was in 600 B.C., then he would have been 70 in 560 B.C. Therefore, 560 B.C. is the latest probable date at which the Samos tunnel could have been started. The date falls within the period considered to be the most likely one from the standpoint of Samos history.

Tentative identification of Eupalinos with the water system at Megara permits ascribing to him another work. Sometime during the rule of Periander, that is,



AIECES AND PYTHAGORAS

The headless figure is that of Aieces, tyrant of Samos, during whose reign were constructed the two earliest Grecian engineering works, the tunnel of Eupalinos and the mole in the harbor of Samos. The other pictures show the head of Pythagoras, generally acknowledged to be the founder of the science of geometry. It is believed that his interest in the subject was aroused or heightened by witnessing the work of Thales in connection with the tunnel at Samos.



GLAUCE SPRING HOUSE

Plan and sectional sketches of the water-supply system in Corinth that is attributed to Eupalinos. Legend has it that after Theseus returned with the Golden Fleece and his wife Medea, he deserted his mate and married Glauce, the daughter of the King of Corinth. Revengeful, Medea sent her two children with a beautiful robe as a present for the bride. When Glauce put it on, so goes the story in Euripides's famous play, the robe burst into flames and Glauce, mad with pain, flung herself into this spring. Above the spring was the tomb of Medea's children.

between 625 and 585 B.C., there was begun in the neighboring town of Corinth what is known as the Spring of Glauce. This remarkable structure was not built in the usual way, but was carved out of a single ledge of rock jutting out of a cliff near the market place. In this monolith are four separate reservoirs and an elaborate system of draw pools and drains. Unfortunately, none of the original piping has been rcovered, but one can compare the drains and draw basins with those of the Megarian fountain house.

As the Greek cities grew in wealth and population, it became a matter of paramount importance to provide an abundance of water. House-to-house distribution of water was, of course, unknown. Greek women were accustomed to dip their water from open wells or basins. As the communities developed, the problem of keeping the basins clean became more and more pressing. This was especially true of Corinth, where lime deposits, as well as mud and filth, were fruitful sources of contamination. In Megara this matter was solved (for the first time so far as is known) by constructing two large settling basins, which also served as reservoirs, with two smaller draw basins in front of them. Drains and interconnections were provided so that any one of the four chambers could be cleaned without interfering with the use of the others. In Athens and elsewhere the dip basins were entirely abandoned and the water was drawn from spouts. The Corinthian spring house with its four reservoirs and four draw basins, is an elaboration of the reservoir idea.

In view of the close coincidence of structural details and nearness of time and place, there can hardly be any doubt that the designer of the Theagenes and Glauce fountains was the same man. That this was Eupalinos is likely from the following additional facts. Samos had an alliance with Corinth during that part of Periander's reign in which the Spring of Glauce was built, and it is reasonable to assume that representatives of Samos visited Corinth at that time. This gave them opportunity to become acquainted with the latest thing in water works and also to learn about the potentialities of large-scale rock excavation. Indeed, the Glauce spring house involved considerable rock removal. The cross section of the reservoirs averages 9x16 feet and the total depth is, roughly, 200 feet.

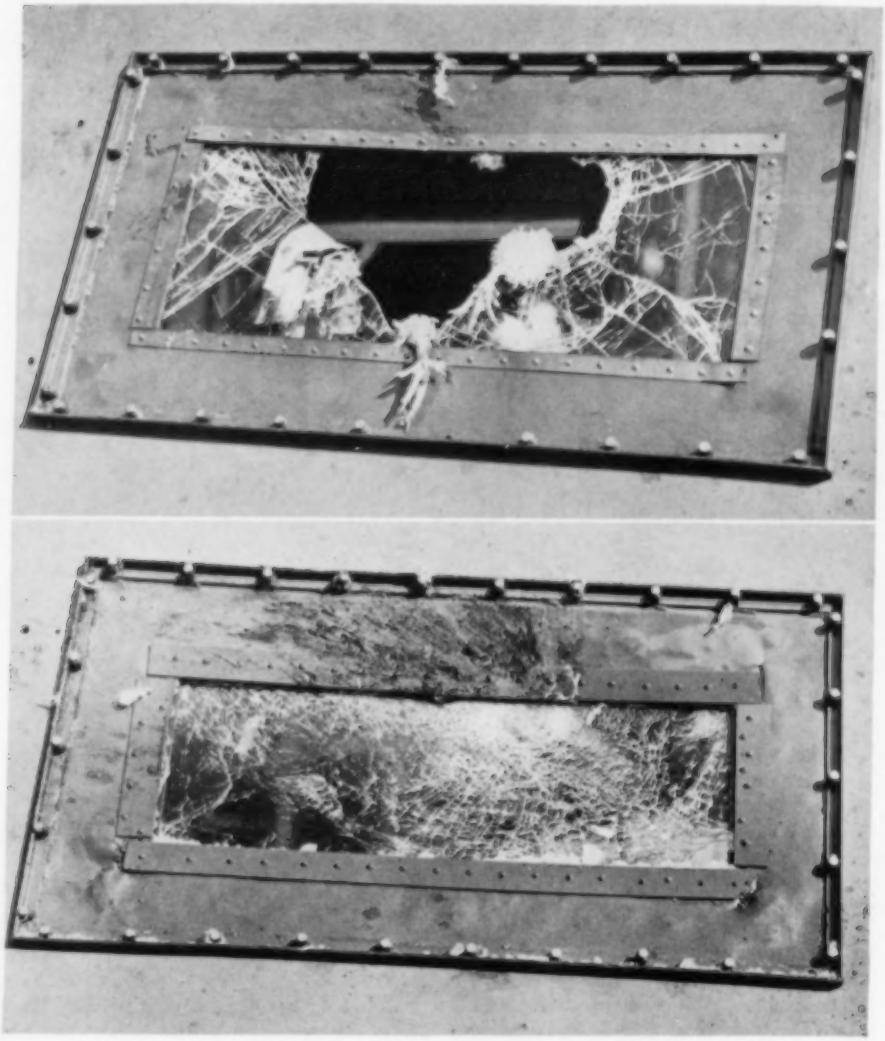
Thus, it is possible, tentatively, to identify as the work of Eupalinos the spring houses at Theagenes and at Corinth, 600 and 590 B.C., respectively, and the tunnel at Samos, 565–560 B.C. If this is correct, one may very appropriately consider Eupalinos the father both of the aqueduct tunnel and of the municipal water system, at least that in which water is drawn from a remote spring and distributed at a central fountain. As the first civil engineer in historic times, well indeed did he earn the "high wages" referred to in the beginning of this article.

Furthermore, by placing the date of the tunnel of Eupalinos in 565, we bring it into the time when Thales, the founder of practical geometry was flourishing in the city of Miletus, only 30 miles from Samos. And since Thales was the one man in Greece who had the knowledge necessary to do the required surveying, it is natural to assume that Thales, with Anaximandros his assistant, was hired as a consultant. If this is so, we can make a very good guess as to the survey methods used. Thales and Anaximandros had just introduced into Greece from Babylon the gnomon or tee square, which they had utilized for both surveying and astronomical purposes. This instrument may have served both as a level to run a line of levels around the mountain and as a transit to run a straight line over it.

There is still one other matter. If the date of the tunnel is correct, then there surely must have been a 15-year-old boy, Pythagoras, among the sidewalk superintendents on that ancient job. Pythagoras is usually considered the true founder of geometry. Although some geometrical theorems were discovered by Thales, Pythagoras first united those theories into a science. Further, he gave to Greek geometry its particular form, which is predominantly concerned with angles rather than lengths and sizes. It is perhaps not too much to suppose that this interest in angle and direction was aroused in Pythagoras while he was watching Thales and Eupalinos lay out pointing stakes in running the survey for the tunnel. If so, it was not the last time that pure science took its key from engineering.

Birdproof Windshields for Airplanes

R. N. Bryan



Courtesy du Pont Company

OLD AND NEW WINDSHIELDS

These pictures graphically show what happens when a 4-pound bird is projected at a speed of 110 miles an hour against the ordinary type (top) and the improved type (bottom) of airplane windshields. The former is smashed and the latter has withstood the impact. The outside pane of fully tempered glass has virtually disintegrated, but the laminated assembly has remained whole. The same plastic is used in both cases except that the sheet in the upper windshield is only 15/1,000 of an inch thick, as against ½ inch in the lower one.

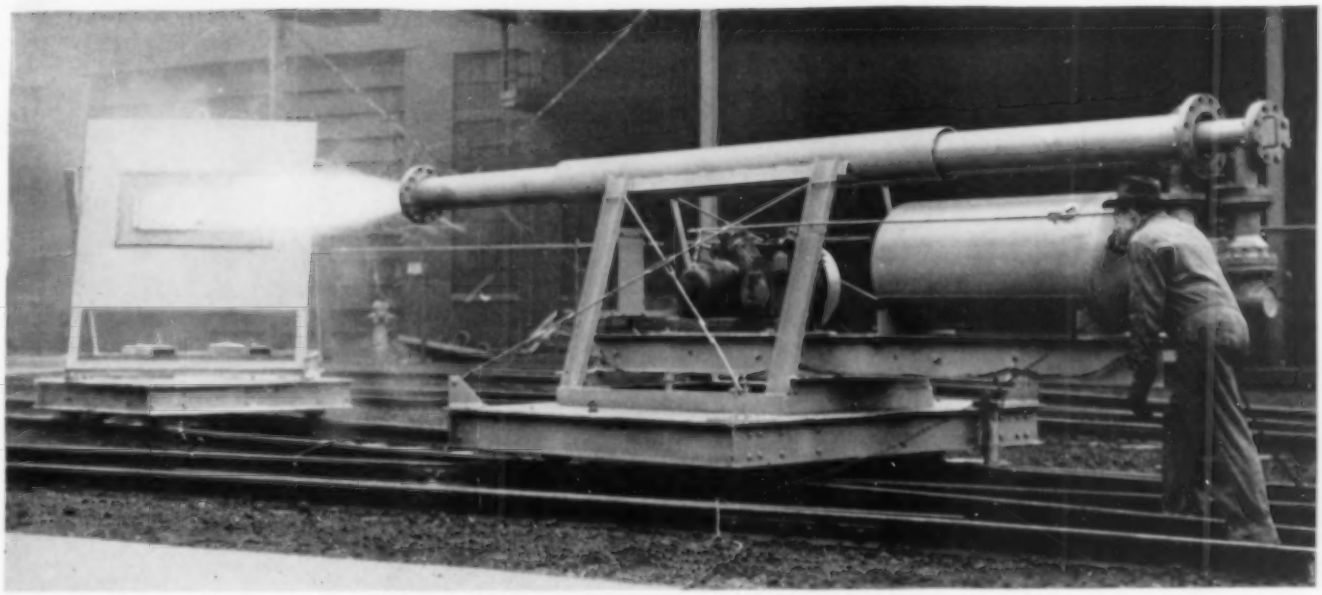
ENTHUSIASTIC naturalists have long been wont to refer to birds as "our feathered friends," and the term is, of course, appropriate in many cases. But, unwittingly, these same creatures can also become dangerous enemies—at least to the crews of our high-speed aircraft. Ducks, wild geese, eagles, seagulls, and other fowl have, on numerous occasions, crashed through the windshields of planes traveling at high velocities. Although this may sound funny to the casual reader, it contains no element of humor for the experienced pilot. In one instance, a bird hurtled through a windshield with such force that it tore its way through the metal bulkhead of the pilot's compartment, continued the length of the plane, and finally burst through the rear partition into the baggage compartment. This is no figment of fancy. It is recorded fact.

Airmen believe that several mysterious crashes, hitherto unexplained, have been caused by collisions with birds in flight. To eliminate the attendant dangers, the Civil Aeronautics Administration is sponsoring a program that has as its object the development of a shatterproof windshield—one that will afford protection to pilots against the menace of soaring birds. Thanks to its efforts and those of several well-known industrial concerns, windshields that answer these requirements are already available.

Until recently, windshields of transport planes were similar to those of automobiles. They were made of two layers of glass with a thin plastic filling in between. This shield could be shattered by the impact of a 4-pound bird when traveling 75 miles an hour and a 15-pound bird at less than 100 miles an hour. Of the new types developed, the most promising consists of a single ¼-inch layer of full-tempered glass and of another panel separated from the first by an air gap. The purpose of this is to provide a space through which hot air from the engine exhaust can be circulated to prevent frosting of the windshield. The second panel is really a "sandwich" affair—a ½-inch sheet of specially prepared plastic between two ⅛-inch layers of semitempered glass. According to A. L. Morse, chief of the CAA's aircraft development section, the full-tempered glass, which constitutes the windshield's outer section, is heat-treated until it is seven times as strong as ordinary glass.

A unique method is used to test the windshields under conditions which simulate those encountered in actual flying. Briefly, bodies of dead birds are shot, one at a time, against the shield by a high-powered compressed-air cannon. The gun is 20 feet long and can be fitted with interchangeable barrels of varying sizes—the latter being necessary to accommodate either small or large birds. The air is supplied by an electrically driven compressor which, together with the air receiver, is mounted beneath the barrel. Pressures normally used range from 100 to 200 pounds per square inch.

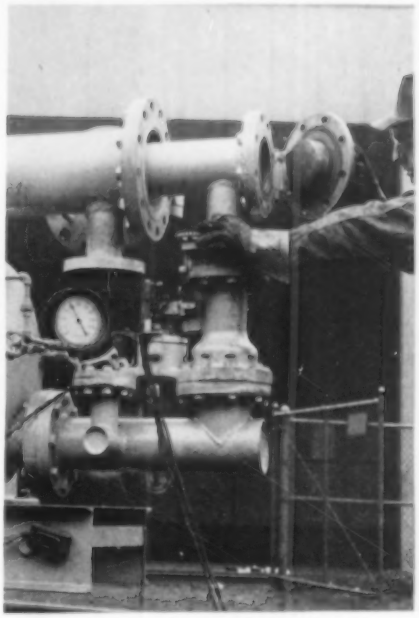
The speed with which the gun operates is assured through the use of an ultra-rapid valve that was designed for a 138,000-kva. compressed-air circuit breaker. This valve is magnetically actuated and releases the air from the storage tank in less than 1/10 second. Velocities of more than 400 miles an hour have been reached, and the tests have proved that the newest



Photos Westinghouse

"FOWLING" PIECE

The 20-foot-long gun that was built to test the impact resistance of airplane windshields to birds in flight. It has interchangeable barrels—one 5 and the other 10 inches in diameter—to accommodate fowl of different sizes. They are propelled at high velocity with compressed air stored in the air receiver and supplied by the Ingersoll-Rand Type 30 compressor mounted beneath the barrel. The compressor is air-cooled, operated by a 5-hp. motor, and delivers air at a maximum pressure of 1,000 pounds. The windshield undergoing test is mounted in a movable frame to permit changing the angle of impact. At the right is the breech mechanism of the gun. Before the freshly killed birds are inserted, each is weighed and stuffed into a flour sack.



windshield will withstand the impact of a 4-pound bird with a plane going 300 miles an hour and of a 15-pounder when traveling more than 200 miles an hour.

What has been accomplished was said to be impossible by experienced fliers, thus showing what can be done by determined effort and coöperation. The organizations that have collaborated in this work, which is being continued to provide windshields offering still greater protection, are: Pittsburgh Plate Glass Company and Libbey-Owens-Ford Glass Company, prepared the glass and did the laminating; E. I. du Pont de Nemours & Company, Monsanto, and other chemical companies provided plastics; the de-icing experiments have been carried out by the personnel of the National Advisory Committee for Aeronautics, aircraft manufacturers, and domestic air lines; the gun was developed by the Westinghouse Electric & Manufacturing Company; and the tests have been conducted at the latter's East Pittsburgh, Pa., plant by the Civil Aeronautics Administration.

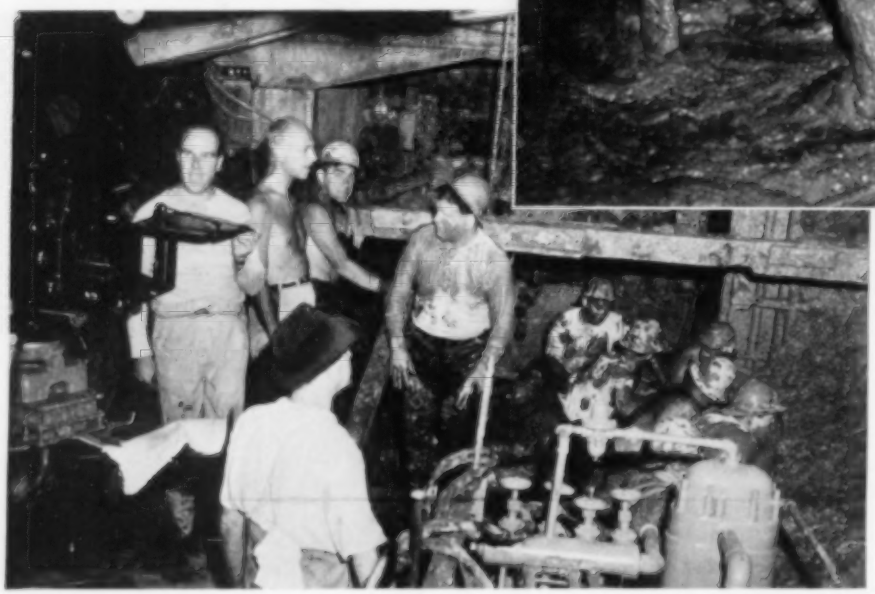
Protective Device for Small Motors

AUTOMATIC devices that protect dynamos, motors, and other electrical equipment against overload are in common use today. This applies especially to large units, less so to motors up to 7½ bhp. For example, modern machine tools are often operated by one main motor and two or three auxiliaries. The former is generally provided with means to prevent burning out through overload, whereas the smaller ones will, more often than otherwise, be damaged under such circumstances because of a lack of protective devices. While fuses will function in the event of dead short circuits, they rarely are sufficiently sensitive to interrupt a circuit in which a small motor is subjected to an overload that would dangerously heat the windings.

In the case of a 3-phase machine, it sometimes happens that one of the three fuses blows not because of an overload but because of imperfect contact of the fuse itself, which arcs and causes overheating. With one phase interrupted, the motor will continue to run as a single-phase unit, taking approximately twice the normal amount of current. As the heat generated in the windings under such circumstances is four times that developed ordinarily, and as there is little to indicate what is wrong, the motor soon reaches a dangerous temperature and burns out.

Now, more than ever, all motors, small as well as large, should be adequately safeguarded against failure through overload, and any and all systems that are designed to do this deserve consideration. What is said to be a simple and unfailing means of automatic control for alternating-current motors of any size working unattended for prolonged periods has been introduced by the Midland Dynamo Company, Ltd., of England under the name of Electromotastat. Essentially, it is a small heat-responsive switch that is embedded in or close to the stator windings of the machine. This switch opens the circuit of a relay, which cuts off the electric supply should the temperature of the windings reach a dangerous point. The switch contacts are hermetically sealed in an evacuated tube and may be arranged to either open or close to operate the relay. As soon as the circuit is interrupted the motor commences to cool down, and when it reaches the right temperature it is again automatically switched on to the line. With working conditions normal, the motor will continue to do its duty, but if the cause of the overload still exists, then the Electromotastat will once more interrupt the circuit.

Hollywood Goes Subaqueous



ROMANCE IN A TUNNEL

In the picture at the right Claudette Colbert, in the role of a newspaper photographer, and Fred MacMurray, cast as a he-man sandhog, wallow in real mud. Below, Director Mitchell Leisen, with torso bared, gives final instructions before shooting a scene in "No Time For Love." The cameraman, Charles Lang, at the left, is apparently perturbed about something.

TO SIMULATE reality in staging one of its recent movies, *No Time For Love*, Paramount Pictures, Inc., reproduced in wood a section of a subaqueous tunnel, accurate in detail even to the shape and size of the curved steel plates that are actually used. This "set" was erected on the studio's longest stage and is reported to have been one of the most complicated construction jobs in screen history. The tunnel was 31½ feet in diameter, and its 150-foot length was divided into three pieces which could be pulled apart or pushed together according to camera requirements.

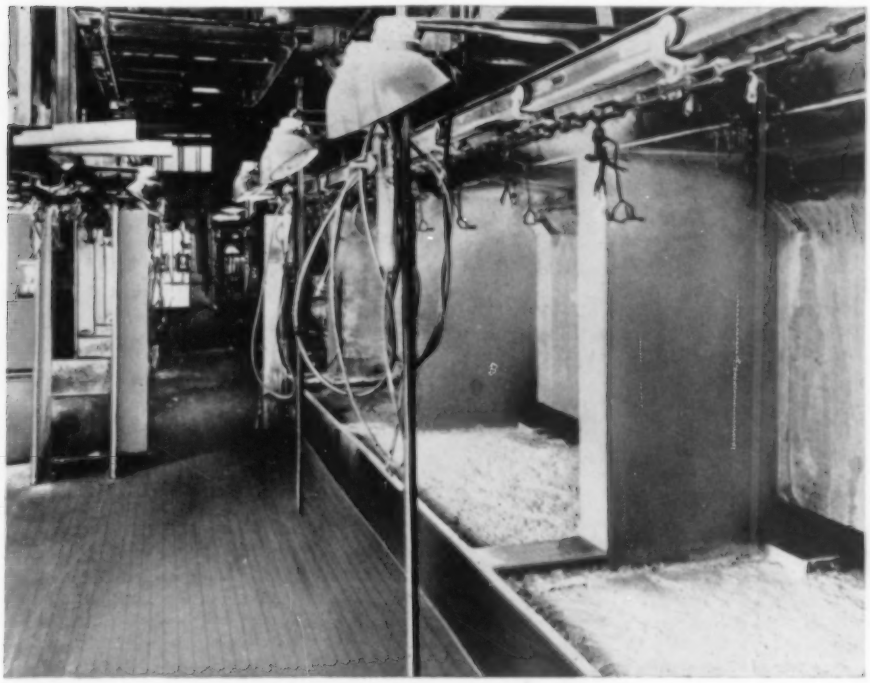
The set was used in photographing a considerable footage of film in a screen romance between a sandhog and a woman newspaper photographer. The principals were Fred MacMurray and Claudette Colbert. To add further realism to the picture, they and others of the cast wallowed for a time in several feet of mud which poured into the bore from a supposed "flow" through the compressed-air shield, with the aid of which the tunnel was being driven. The mud consisted of a mixture of mineral gelatine, fireclay, and water. More than 37 tons of it was used, and to obtain the effect of irresistible power when the shield gave way it was introduced into the bore under great pressure through hydraulically operated steel doors. Although only a few minutes were required to depict this action on the screen, its filming took ten days, and a studio publicity man is authority for the statement that Miss Colbert "never before has been so thoroughly messed up for her art." During the course of the picture she wore seventeen separate costumes, many of them glamorous, but fashion was cast aside in several of the tunnel scenes in which her nether parts were encased in hip-length boots.

Construction of the tunnel set required 17,000 board feet of lumber, most of which was obtained from the studio's stock pile in conformity with an order clamping a $5,000-per-set ceiling on new materials. Even then its cost was close to the authorized limit. The work was in charge of Lou Vance, a studio technician who had never seen such a tunnel but who holds two engineering degrees. For guidance he had photographs and blueprints of the shield used by the Walsh Construction Company in driving the Queens-Midtown Tunnel underneath the East River in New York.

As a precaution against straying too far from actualities in the film, Paramount enlisted as technical adviser Charles Wall, a civil engineer on the staff of the New York City Tunnel Authority. Mr. Wall has been identified with all the compressed-air tunnels driven in the New York area during the past fifteen years, and upon checking the set he found it to be a remarkably faithful representation of the real thing. Even the bolts with which the segments of the steel or cast-iron lining are held together were in their proper places, although the wooden lining plates were nailed. The set was open at the top to permit suspending platforms from which the cameramen obtained shots from the desired angles. Although the tunnel skeleton, erector arm, shield, and other parts of the set were not genuine, some of the equipment was. The railroad track, two 4-ton locomotives, and six muck cars were obtained for the purpose from L. E. Dixon Company, a Los Angeles contracting firm, and had been used on actual construction jobs.

Only one of the actors who assumed the roles of sandhogs had ever worked underground. He is Rod Cameron, who lived in New York before going into the movies. The other screen tunnelers were recruited from among Hollywood extras, and the concensus of opinion of those who are versed in such subaqueous work and who have seen the film is that they did a creditable job. The picture was directed by Mitchell Leisen who, according to Paramount's publicity staff, dived head first into the tunnel mire after the final scene was filmed, just to show the cast that he wasn't above getting himself as dirty as they were.

Salvaging Waste Paint



WATER-WASH SPRAY BOOTHS

Here is shown a typical conveyor line with booths such as are widely used in "mass" air-spray painting. Floating on the surface of the water in the two tanks in the foreground is paint overspray that was previously wasted but from which critical materials such as glycerine, natural gums, oils, formaldehyde, nitrocellulose, plasticizers, chromium, zinc, lead, etc., are now reclaimed by separating the water from the paint ingredients and by redissolving and clarifying them.

THE recovery of critical materials from wasted paint is one phase of the general program aimed at getting into the production stream all salvageable chemicals vitally important to the war effort. A national survey of the paint situation, made by the Industrial Salvage Branch of the War Production Board, has revealed that approximately 50,000,000 pounds of paint ingredients can be recovered during 1943 through coöperative action by the paint-manufacturing industry and the consumers of its products. There are available only limited supplies of many of the materials used in the making of paint. The pigments contain, for example, such metals as chromium, zinc, lead, and iron. Other basic substances that enter into its manufacture are now required in the production of explosives. Needless to say, these commodities are more vital today than they were at any previous period in our history.

Many of the items that come off the assembly lines of the war industries are spray-painted by means of compressed air. This is where waste, usually called "overspray," occurs, and it is known that about 30 per cent of the paint used in this work can be recovered. In fact, since methods of reclamation have been perfected, nearly 3,000,000 gallons of paint have been salvaged, and it is said that the reclaimed product is equal in quality to the virgin material. The recovery processes vary, depending upon the composition of the paint. In general, the steps comprise removal of the water, redissolving, clarifying, etc. The different procedures may, roughly, be separated into three groups: one for lacquers, another for oil-base and straight-alkyd mixtures, and a third for urea-formaldehyde finishes.

Inasmuch as intelligent coöperation by the consumer is a prerequisite of successful reclamation, it may be well to outline the precautions that he should observe in collecting the overspray. The quality of the salvaged paint and the cost of recovery will depend largely upon the care with which this work is done. In general, only one kind of paint should be sprayed in a water-wash unit, which is equipped with a tank to collect the overspray. In some cases the same booth may be used for two, provided there is a cutoff point and the collected overspray is removed; but the two different oversprays should not be mixed. Where segregation is not practicable, however, recovery of a mixture of two or more colors of compatible types of finishes may be worth while if the salvaged material is of a neutral color and can be used to advantage as an undercoat, ground coat, sealer coat, or finish for concealed parts.

Contamination of paint overspray by foreign matter must be avoided. Obviously, the presence of metal objects in the collected overspray—objects such as conveyor hooks, spray nozzles, bolts, etc. —will damage the reclamation machinery. Food refuse contaminates the paint with particles that disintegrate later and cause film failure. Gloves and rags, which are carelessly permitted to drop into the overspray and may be ground up with it, introduce materials that are often impossible to remove by filtering. The same is true of paper and cardboard.

Scrapings and sweepings of overspray from dry parts of a booth should not be added to the water-wet overspray. In rare instances, where a relatively nonoxidizing finish is sprayed, is it feasible to convert dry overspray into usable material. Where such overspray is found to have a salvage value, it should be scraped off as frequently as possible and immediately placed under water. To avoid oxidization, accumulations of overspray should be kept covered with water at all times. Once the vehicle in the paint is exposed to the air and oxidization has occurred, the material becomes useless for recovery purposes. Overspray should be removed from the tanks at regular intervals. This work is generally done during the lunch period and at the end of each shift.

Caution must be exercised in the selection of cleaning compounds for water-wash spray booths. Although such chemicals are usually required to keep the overspray from fouling the flood sheet, the nozzles, and the circulating system, there is frequently a chemical reaction between compound and paint that lowers the quality of the reclaimed product. The choice is best determined by trial in each individual case. The following general rules should govern the use of overspray recovery agents: first, use the minimum amount necessary to keep the spray-booth system clean and to yield a reclaimable material; second, keep a record of additions of compound and of the alkalinity of the water; third, key the foregoing data to the removal of the various lots of overspray. The purpose of this is to enable the reclaimer to trace the reasons for improvement or impairment of the quality of the overspray from lot to lot.

Collected overspray should be placed in clean, open-head drums awaiting return to the mixer and should be covered by at least 4 inches of water so that oxidization cannot occur. It must not be stored for prolonged periods where the temperature is above normal.

Ship Tonnage Defined

PAT, the hod carrier, was sent by his boss to measure a short stretch of walk. And for that purpose he was given a folding foot rule. When Pat came back and was queried: "Did you get it?" Pat answered: "Shure, Sor. It was double the lingth o' the rule, half agin the lingth o' me arm, and as long as this shtick and this piece o' shtring." The ways of measuring a ship are as diversified as Pat's procedure. In the case of a Liberty Ship, for example, the term tonnage is applied variously, and each has its own significance. There is displacement tonnage, dead-weight tonnage, cargo-capacity tonnage, gross tonnage, and net tonnage. These are confusing to most people, and yet, with their wide differences in numerical value, they may be applied to the same vessel.

A ship in any state of lading floats because it has actually displaced an equal weight of sustaining water. Therefore the naval architect uses displacement tonnage as his basic yardstick of measurement. Each ton of sea water displaced represents 35 cubic feet, and each cubic foot weighs 64 pounds—the displacement ton being the same as the familiar long ton of 2,240 pounds. A vessel's displacement may range from her lightest condition afloat to her deepest draft when laden to the permissible maximum. Displacement light is her weight *excluding* cargo, passengers, fuel, water, stores, etc., when being made ready to go to sea. Displacement loaded is the total weight, *including* cargo, passengers, fuel, water, stores, etc., aboard when about to leave port.

Dead-weight tonnage, also measured in tons of 2,240 pounds, is the difference between displacement loaded and displacement light, and is the carrying capacity of a craft. The cargo-capacity tonnage is the number of tons left after the weight of the fuel, water, stores, and other items necessary for use on a voyage has been deducted from the dead-weight tonnage. To the owners and operators of a ship, this tonnage is of greatest interest because it directly concerns revenue-making.

Gross tonnage, which is expressed in tons of 100 cubic feet, is the entire internal cubic capacity of a vessel—in short, just space, of which a considerable percentage is not available for use. On the other hand, net tonnage represents "earning space"—the space remaining after certain deductions have been made from the gross tonnage to provide accommodations for the crew and room for propelling machinery, for navigational apparatus and facilities, and for some other essential structural or operating needs.

There is still another characteristic of a craft—her bale cubic capacity—that is, space for cargo, and this is measured in cubic feet in the holds from inside surface to inside surface of opposed battens on the frames or ribs of a ship and from the floor of the cargo hold to the underside of the beams of the deck immediately overhead. Of course, what goes into this space depends upon the nature and the weight of the shipments. The only restriction is that the vessel's maximum dead-weight tonnage shall not be exceeded.—*R. G. S.*

Postwar Planning

FROM every side we hear talk about postwar industrial planning, garnished with glowing descriptions of the improved products that are going to revolutionize our way of living. This is unfortunate, for it is tantamount to saying that the war has been won and that manufacturers can now go ahead designing new machines and gadgets to cater to our enjoyment in the peacetime era that is to come. Some persons are so certain that current models of autos, refrigerators, etc., will soon become obsolete that they would not buy them now if they could.

This mania of Americans for discounting the future may have unpleasant repercussions. The most competent authorities agree that we are not yet fully prepared for winning the war. Paul V. McNutt, chairman of the War Manpower Commission, says that 5,000,000 additional workers must be inducted into war industries before the end of this year, and Lieut. Gen. Brehon B. Sommervell, commander of the Army Service Forces, declares that our armed forces will not be fully equipped until the end of 1944. In spite of these official statements, postwar planning conferences are being held by many trade organizations, and advertisements of various industrial concerns now engaged 100 per cent in war work are being sweetened with the sugary propaganda of better things to come.

Travelers recently returned from abroad say that we alone are indulging in this pleasant pastime of daydreaming. Prime Minister Churchill quickly scotched this sort of thing in England by advising his countrymen to "keep their eye on the ball and get on with the job of winning the war." Russia still puts the war first, and is offering prizes up to $30,000 for ideas that will increase the efficiency of munitions production. There is definite evidence also that the Axis countries are not allowing thoughts of peace to interfere with an all-out effort to evade defeat.

These better products are coming eventually, but if the war is to be won they are going to be developed later and not now. Fortunately, some of our largest industrial concerns have not been swayed by all this loose talk about postwar planning. The Automotive Council for War Production states that no automobile manufacturer is working on postwar cars, and that there will be no experimental work on new models until the war is won. The first peacetime cars produced will be essentially prewar models. One of our largest electrical manufacturing concerns has likewise informed its dealers that they will get old-line refrigerators and appliances to sell when the war is over.

Nobody knows whether this game of war we are now playing is in the second or seventh inning. Let's keep our eye on the ball, as Mr. Churchill urges, until the Axis team has been thoroughly shellacked.

Log of Our War Economy

THE following paragraphs contain significant bits of information culled from official press releases sent out by the War Production Board.

MAY 18—The Department of Labor announced that improved seating facilities for workers will increase output. One plant, for example, found that special "sit-stand" seats in a metal-polishing department served to boost production about 32 per cent. Study further revealed that excessive standing or improper seating do not make for peak production and may cause accidents.

An amended WPB order permits the use of copper in the manufacture of starting motors and headlights for farm tractors. The purpose is twofold: to enable men and women who cannot crank engines by hand to run the tractors and to use the machines for nocturnal operations.

Secretary of Agriculture Wickard announced that a new type of lignin plastic made from farm wastes can be substituted for metal for many purposes, including certain military supplies. Scientists who conducted the research state that the plastic can be produced from corn stalks, wheat straw, flax shives, and other fibrous materials; that it hardens under heat or pressure; and that it calls for the use of only half as much critical phenol-formaldehyde resin as do other plastics of this type.

A coast-to-coast scrap-hunting campaign by Boy Scouts and Junior Cubs is expected to gain momentum as soon as schools close for the summer. These two groups, which have a membership of more than 1,200,000, will make overnight camping trips in an effort to discover heavy scrap that can be hauled to points of disposal. The boys are already making store-to-store surveys and visiting many industries to round up waste material.

Inventories of used construction equipment set up in WPB's twelve regional offices have, during the past six months, aided in placing more than 7,000 such items on jobs throughout the country. Valued at $60,000,000, they have saved a corresponding amount of new machinery, or 120,000 tons of raw materials.

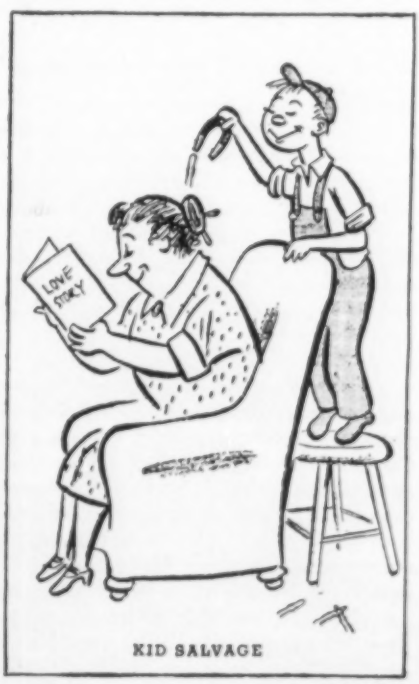
MAY 21—A representative sample survey published by OWI indicates that 58 per cent of the nation's small manufacturing concerns are engaged directly or indirectly in war production. Of the remaining 42 per cent about one-fourth has been unable to obtain war-production contracts; the others have not tried to get them. Only companies employing not more than 125 wage earners were included in the survey. Actually, less than 5 per cent of those investigated had more than 80 on their payrolls.

Experiments in the growing of *kok-saghyz*, the Russian rubber-producing dandelion, are being conducted on the Bureau of Reclamation's Klamath project in Oregon and California. The aim of this year's planting is to procure seed. The advantage of *kok-saghyz* over other rubber-yielding plants is that it can be harvested and processed in a single year. In 1942 a trial plot on the Klamath Experimental Farm produced at the rate of 50 pounds of rubber per acre.

MAY 22—More quartz crystals are needed for the manufacture of quartz oscillator plates used in military radio equipment. Anyone who knows where to obtain such crystals is urged to get in touch with the Miscellaneous Minerals Division, War Production Board, Washington, D.C. Only separate, individual crystals are wanted; clusters, groups, or grainy masses will not do. Clear, colorless quartz is best; milky, rose, and purple varieties are useless.

JUNE 1—As a result of a survey conducted at home and overseas, OWI offers the following suggestions regarding letters to service men: Tell what the family is doing to help win the war; give news of its other activities; describe what is going on in the community; include information about friends, favorite athletic teams, etc. Don't bother the recipient with tales of troubles and complaints, and don't burden him with a recital of financial difficulties unless he is in a position to help.

JUNE 2—Silver-lead instead of tin-lead solder is to be used for 40 per cent of the 1943 cans for foods, household products, etc. In 1944 the figure will be increased to 70 per cent. The saving in tin in the 2-year period will amount to approximately 8,000 tons. The silver-lead solder contains about 2.5 per cent silver, 5 per cent tin, and 92.5 per cent lead, as against 30 to 40 per cent tin and 60 to 70 per cent lead for the other.



KID SALVAGE

From the OWI.

JUNE 3—The sizes of rotary files that may be manufactured has been reduced from 380 to 70 by a WPB order. The object is to save high-alloy steel and to speed production. Those of large size can be reground from 20 to 30 times, say WPB officials, who urge that regrinding be done whenever possible. Shanks for rotary files of ½-inch diameter and up will be made of carbon steel only.

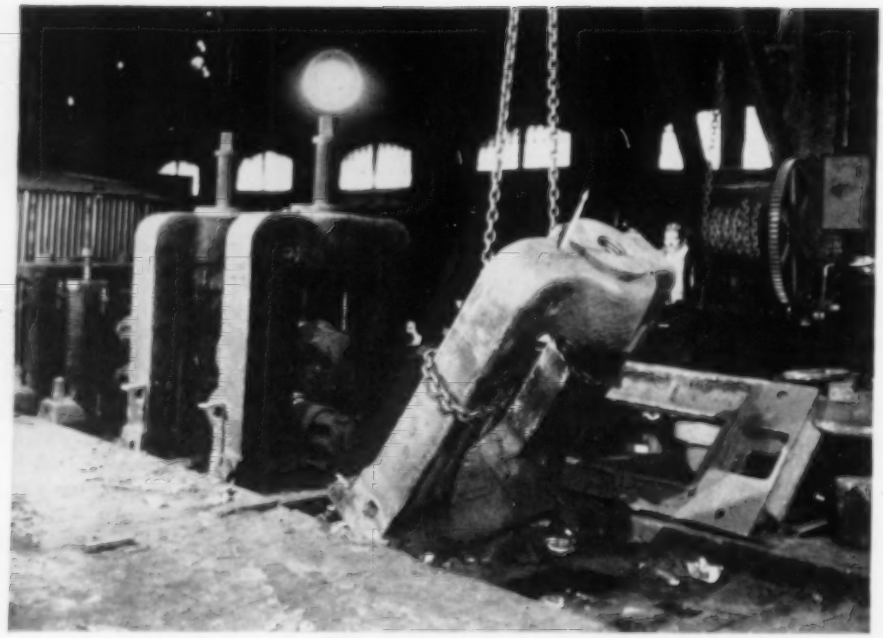
In May, another record-breaking month, American shipyards built and delivered 175 vessels totaling approximately 1,782,000 dead-weight tons. During the first five months of 1943 were constructed 711 of 7,142,122 dead-weight tons—only 35 ships less than were produced in all of 1942.

JUNE 5—Repair and maintenance of agricultural tillage equipment and machinery will be facilitated by the recently amended WPB Order L-223. It permits the use of certain low-alloy hard-facing compositions for such purposes on orders rated AA-4 or higher.

National Housing Administrator John B. Blandford, Jr., has announced the fact that more than 1,100,000 housing units for occupancy by essential war workers have been placed under construction since the start of the defense program in July, 1940. By the end of April, 1943, a total of 813,000 had been built and 309,400 were in varying stages of completion. About 454,000 of the former are privately financed family dwellings.

JUNE 7—WPB lifted all restrictions on the finishing of men's and boys' wool trousers, thus permitting their sale with or without simulated cuffs. Limitations on trouser lengths continue unchanged. An average turn-up of 3 inches of material is allowed, enough for a cuff, but that is all.

JUNE 13—Secretary of Labor Perkins stated that labor and management must take the initiative in working out mass feeding facilities if war workers are to have a well-rounded diet. "The Women's Bureau," said Madame Perkins, "has formulated standards for eating periods for women in war plants—a minimum of 30 minutes' time, a menu that includes hot, nutritious foods at a reasonable price, and a pleasant place in which to eat away from the workroom."



DRAFTING THE SCRAP

What looks like the symbol of the Rising Sun leers in the background, left, as 20 tons of dormant scrap is dragged away to make life miserable for Hirohito's war lords. The housing of a 3-stand sheet mill is being dismantled by Henry Disston & Sons, Inc. Hitler would give the brown shirt off his back to get his hands on a little of Standard Oil's petroleum to run his war machine. The picture below shows all that he's getting—tar heat exchangers weighing 35 tons that are being relegated to the scrap heap at the Richmond, Calif., refinery. As tar heat exchangers they're obsolete, but as Berlin-bound bombs they're this year's models.

Scrap Saves Man-Hours

SCRAP is a trade term for salvaged materials. Industry uses scrap to make its supplies of primary or raw materials go farther. For example, the production of ships, tanks, guns, planes, trucks, and other war equipment is limited to a large extent by the supply of metal scrap. Steel can be made without scrap, but only in such insufficient quantities that the war effort would be severely handicapped.

Each pound of scrap used in making steel replaces a pound of pig iron. For instance, to produce new steel, scrap iron and pig iron must be melted together, half and half, in open-hearth furnaces. To make one pound of pig iron requires nearly 4 pounds of ore, coal, and limestone. When you turn in a pound of scrap you also conserve 4 pounds of vital war materials. Translate this saving into terms of the 6,000,000 additional tons of scrap (over and above normal requirements) that we need today, and we have the equivalent of 12,000,000 tons of iron ore, 7,200,000 tons of coal, and 3,000,000 tons of limestone. Think also of saving the millions of man-hours involved in mining, transporting, and processing these 444,000 carloads of raw materials—enough to form a solid train stretching from Boston to San Francisco.

The scrap that is recognized as such is only a small part of the actual scrap in the average plant. Obviously, all the materials in a plant, fabricated or unfabricated, are scrap if they are not performing useful services. Obsolete machines, outdated dies, jigs, and fixtures, old pipe lines, valves, and fittings, unused supplies—all are dormant scrap. The more you salvage, the greater the manpower, materials, and machines released for the all-important task of winning the war.

Air-Operated Impact-Type Stamping Machines

UNDER the head of *Cecostampings*, the Chambersburg Engineering Company has published a bulletin that fully describes and illustrates its line of high-production impact-type stamping machines that have been developed to form hard-to-forge metals such as stainless steel and aluminum alloys. According to the manufacturer, Cecostamps are designed especially for thin, hot work that cools quickly, for embossing, and for short-run or small-quantity work. The dies used in the latter case are cast of lead and zinc (occasionally they are made of wood, aluminum, and magnesium) in plaster molds and can be recast.

The machines are operated by means of an air cylinder with differential porting—that is, a smaller top than bottom port. On the down stroke, the ram falls faster than it would if both ports were of equal area, and on the up stroke the fast, unrestricted inrush of air makes for faster reversal and uptake. Movement of the ram is controlled by a balanced piston valve that is actuated either by a cam for automatic operation or by a hand lever. As the latter is moved up and down so does the ram go up and down, making it possible to deliver at will a series of light, fast blows; to strike powerful blows with full air pressure on the piston; or to give the work a squeeze at any point in the forming process. By the use of adjustable stops, the travel of the lever can be limited so that blows of like intensity can be struck from a fixed height.

Overtravel of the ram is prevented by a safety piston that surmounts the working cylinder and is under live air pressure when the unit is in service. An added safety feature are positive latches that hold the ram in an elevated position when changing dies or working between them. These latches are actuated by pneumatic cylinders that are operated by the foot-valve that controls the air supply to the main cylinder. The volume of air used varies from 60 cfm. for a 30x24 Cecostamp to 880 for Size 120x120 (working area of the ram in inches). The machines come in numerous standard sizes to meet present-day metal-forming requirements.

Industrial Notes

Experiments are being conducted in the United States and in India with bamboo as a substitute for steel in reinforcing concrete.

Laboratory tests of a new reduction process are the basis for a claim that the yield of mercury from cinnabar can be increased from 75 to 99 per cent at one-half the present cost of production. The method was developed by a Glenwood, Ark., geologist and engineer; and a pilot plant has been built to substantiate the laboratory findings.

In describing its new restorer for hard, stiff paint brushes, the Technical Development Laboratories explain that it differs from solvent cleaners in that the bristles absorb the liquid and swell, cracking off the hard paint in doing so. Rinsing under tap water removes the paint. After drying, the bristles return to normal size. The liquid can be reused, and is said to be noninflammable, nontoxic, and harmless to the skin. It is sold under the name of Prestorer.

It is reported that the U.S. Bureau of Mines and the Atlantic Refining Company are coöperating in an effort to develop a fuel combining oil and coal—colloidal fuel—that has for years been the goal of chemists and engineers. Such a fuel would, it is claimed, reduce by about one-third the amount of oil required by heating, power, and similar equipment and would go far towards alleviating the petroleum shortage along the Atlantic seaboard.

Anti-Korode is the name of a paste that is said to check and to prevent corrosion on storage-battery terminals, connectors, and cables. The material is applied by brush with the cables in place and forms a nondrying coating that shields the metal against acid attack. It is a product of the Arsco Chemical Company and comes in 2-ounce jars or 2-pound cans.

"Use the air you need but don't waste it" is the theme of industrial posters sponsored by Ingersoll-Rand Company, manufacturers of compressors and air-operated tools. Their primary purpose is to wage war on leaky hose couplings, valves, and other fittings that all too frequently slow down production because of power losses. Done in two colors, the posters make generous use of splash illustrations that attract the eye and tell their messages in a few seconds. Some are of a warning nature, others are educational in character, showing what to do and what not to do, the right and the wrong way of handling and coupling hose, etc. Put up in conspicuous places they should be effective in the campaign against compressed-air wastage and bad practices. Five different posters are now available; others are in preparation. Plants desiring copies should direct their requests to any of the company's branches or to its head office, 11 Broadway, New York, N.Y., specifying the number desired.

Resharpening will increase the life of a hand file approximately 60 per cent at from one-half to one-third the cost of a new one, according to the finding of a survey made by the Tools Division of the WPB. Industrial plants are urged to have their files reconditioned and thus be instrumental in bringing about a saving of something like 600 tons of high-carbon steel annually.

Rechargeable flashlight batteries are nothing new, but they are mighty useful now that it is next to impossible to get dry cells. One type that was introduced about three years ago for industrial and utility service fits all popular 2-cell 1¼-inch Size D cases and is said to replace 400 and more dry cells. It is made by the Ideal Commutator Dresser Company, to-

TOMORROW'S SPECIFICATIONS WILL INCLUDE NAYLOR LIGHT-WEIGHT PIPE

POST-WAR REQUIREMENTS CALL FOR THESE NAYLOR ADVANTAGES

Always accurate in diameter.
Concentric ends match correctly.
Easier to install.
Holds true cylindrical form.
Stays tight and leakproof.
Stronger—safer.
High salvage value.
Light weight saves steel.
Cuts maintenance costs.
Saves money.
Sizes: 4" to 30" in diameter—all types of fittings, connections and fabrications.

No question about it! Naylor Pipe with its exclusive Lockseam Spiralweld structure has what it takes to do the job that will be required when peace comes.

The outstanding performance of this distinctive lightweight pipe on the battle fronts points the way to the solution of many mine-piping problems in the post-war period.

Write for Naylor Catalog

Naylor

LOCKSEAM SPIRALWELD PIPE

NAYLOR PIPE COMPANY
1245 East 92nd Street
Chicago, Illinois

gether with single- and gang-type battery chargers for use on both alternating and direct current.

Women workers who handle hot airport landing lights in course of production at a Westinghouse Electric & Manufacturing Company plant wear air-cooled asbestos gloves. Attached inside the gauntlet of each of them is a rubber tube connected to an air line that supplies low-pressure air.

America's fighting men in tropical jungles are now armed against malaria and yellow fever with a new "health bomb" that exterminates disease-carrying insects such as flies and mosquitoes. The dispenser is of the throw-away type and is being made by the Westinghouse Electric & Manufacturing Company. It

is loaded with 1 pound of liquid insecticide which is released as a fine mist that remains suspended in the air. In the twelve to fourteen minutes required for complete discharge, one bomb will fumigate 150,000 cubic feet of space, or the equivalent of 240 Army pup tents. However, the spray can be turned on and off to disinfect smaller areas. These "health bombs" are discharged frequently in the barracks and tents of troops stationed in the tropics, as well as in the cabins of every airplane—military or civilian—that takes off from a tropical base. In this way the Army hopes to reduce sharply the casualty rate of past wars during which sickness incapacitated as many men as did bullets and to prevent the spread of disease. The insecticide was developed by Dr. Lyle D. Goodhue, a Department of Agriculture chemist, and is harmless to humans.

To give your wooden core boxes and foundry patterns increased life, surface them with metal, says Alloy Sprayer Company. The equipment used is self-contained and designed to spray low-temperature alloys that are fused in an electrically heated pot and applied with compressed air. In the case of relatively soft or open-grained wood the metal can be sprayed on directly, while hard or close-grained wood has to be shellacked. The thickness of the coat varies from 0.002 to 0.005 inch, except where there are holes and worn places which can be filled and built up as needed. After cooling, the surface is sanded to give it the desired finish.

The Electric Storage Battery Company has announced a new Exide emergency lighting unit for service anywhere where wartime activities have multiplied the danger of power-line failure. The unit is self-contained and requires no fixtures or wiring other than alternating-current plug-in connections. It is provided with a sealed-glass, prefocused auxiliary lamp similar to that used on automobiles and with a 3-cell glass-jar battery that is recharged automatically, pilot balls indicating the state of charge. The Exide Lightguard is said to throw a beam 50 feet wide a distance of 150 to 200 feet and to require no maintenance other than the occasional addition of water.

Workers that are required to wear goggles are, more often than otherwise, careless about keeping them clean. Their intentions are generally good, but maybe there is nothing handy with which to wipe them. To remedy this situation, the Mine Safety Appliances Company is offering a goggle cleaning station, a compact case that is designed for wall-mounting

and that dispenses a lens-cleaning and antifogging agent named Fogpruf, as well as optical wiping tissues. There is a receptacle at the bottom for discarded tissues. Placed within convenient reach of workers there is no excuse for dirty glasses, which are known to be a cause of eyestrain and lowered efficiency.

A patent has been applied for on a process for the conversion of soft, porous and partly hydrated iron ores into dehydrated, hard, dense ores for open-hearth furnaces. The patentee, R.H.B. Jones of the geological department of the Oliver Iron Mining Company, says that the change is effected much as it is in nature and does not call for the use of any cementing material that might be harmful to the charge. If the claims made for it are correct, the process will be of great benefit to the steel industry because the supply of both hard ore and scrap iron for open-hearth practice is limited. The amounts of scrap and pig iron now required are approximately the same; but with more hard ore available, the need for scrap iron would be proportionately reduced.

A NEW STANDARD

CLASS 9213 TYPE AH3 PRESSURE SWITCH

For the garage-type air compressor, ratings up to 1½ H. P. 110V, 2 H. P. 220V single phase, 3 H. P. 220V polyphase and 1 H. P. 550V single and polyphase, use the 9213 AH3. The pressure limit is 200 lbs., adjustable range and differential. Direct connection to release valve without fittings. Priced right.

SWITCH—PROTECT—REGULATE . . . DO IT ALL WITH SQUARE D

SQUARE D COMPANY • REGULATOR DIVISION • DETROIT

FRANCE "FIRE CHECKS"
DEFY BURNING GAS ENGINE HEAT

Packings for double-acting gas engines need protection against the terrific heat and explosive pressure.

The France Sheathed Bronze Fire Check is an ingenious combination of cast iron and bronze. Around a rapid heat-conducting bronze ring, France throws a protecting sheath of heat-resisting cast iron. The cast iron sheath, absorbing heat only one-ninth as fast as the bronze, shields the bronze from direct contact with burning gases, and completely covers the joints in the bronze ring segments. These rings have proved their value under the most adverse conditions of overloading.

If your engine does not have a France packing case, France Fire Checks may be obtained for the case you have. An informative data sheet of France Fire Checks will be mailed promptly at your request.

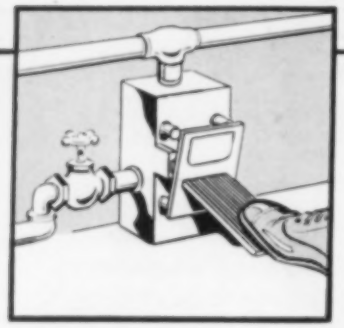
★ FRANCE PACKINGS and PISTON RINGS ★

FRANCE MFG. CO.

FRANCE MANUFACTURING COMPANY

Belgrade and Orthodox Streets, Philadelphia, Pa.

NOBODY WANTED THIS JOB UNTIL.....



....COMPRESSED AIR POWER WAS APPLIED

The machine was a power-driven paper cutter, but the clamp had to be held down by a manually operated foot treadle. The operator had to put most of his weight on the treadle, reach the safety release lever with his left hand, and pull the cutter control lever with his right.

Not too bad a task for a while—but a back-breaker on an all-day basis.

One of the operators suggested a simple change . . . compressed air to take the place of manual effort. Now, instead of throwing his weight on the treadle thousands of times a day, he simply actuates an air valve with his toe.

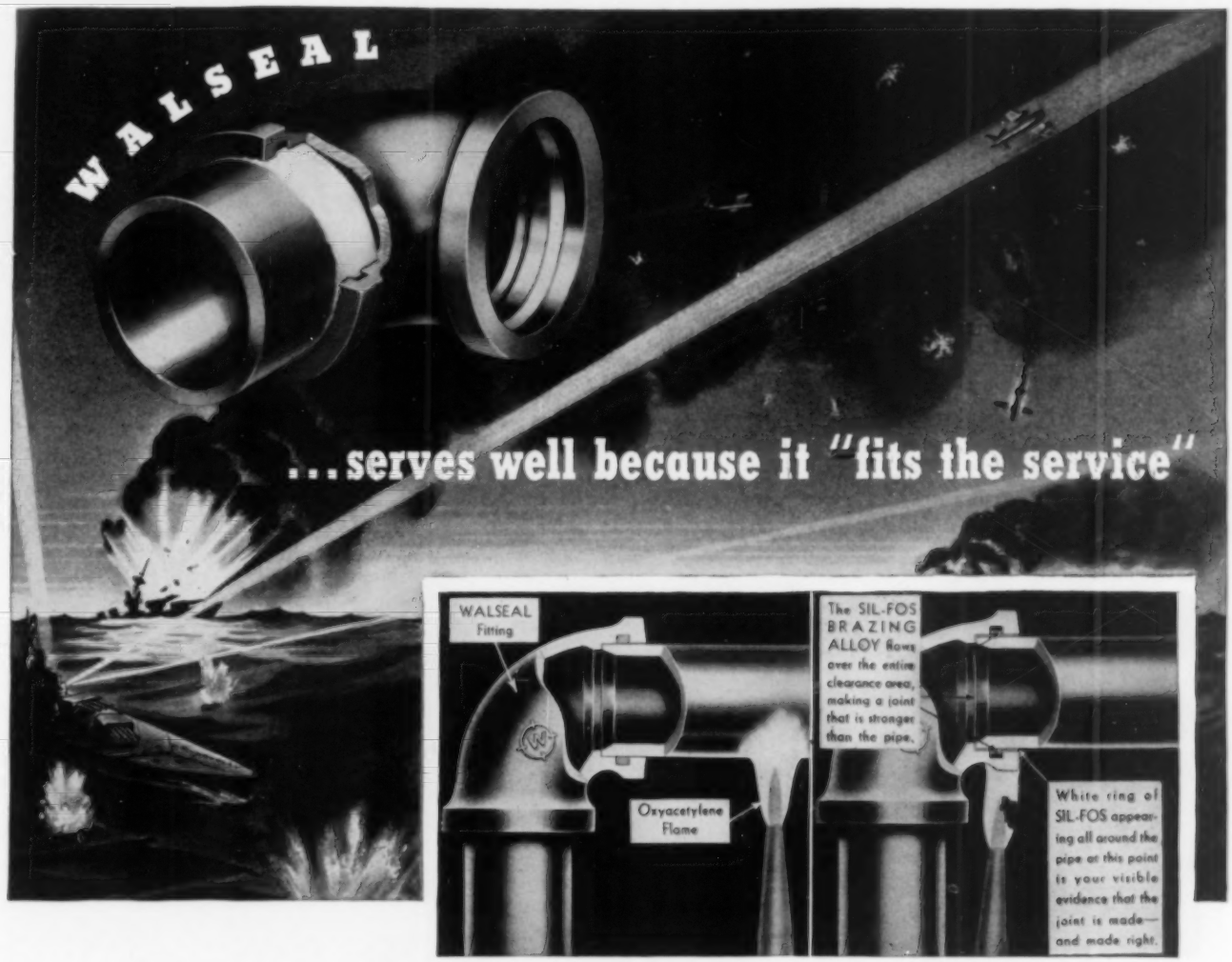
Compressed air can turn a lot of hard jobs into easy ones, and at the same time increase production. An Ingersoll-Rand engineer will be glad to help with your pneumatic problems. Just call the nearest I-R office.

Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.

14-319

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES


WALSEAL
...serves well because it "fits the service"
WALSEAL Fitting
Oxyacetylene Flame
The SIL-FOS BRAZING ALLOY flows over the entire clearance area, making a joint that is stronger than the pipe.
White ring of SIL-FOS appearing all around the pipe at this point is your visible evidence that the joint is made—and made right.

Vibration proof, corrosion resistant, and leakproof! Yes, a Silbraz Joint made with Walseal Flanges, Fittings, or Valves has the inherent stamina to withstand the incessant shaking, the moisture, the changing temperatures, and inevitable knocks of war-time service. Tens of thousands of Walseal products are proving beyond dispute that they truly make a "one-piece pipe line." A Silbraz Joint cannot creep or pull apart under any temperature to which brass or copper pipe can be safely subjected.

Today Walseal is "all out" for war. In the peace to come the use of Silbraz Joints for assembling non-ferrous piping will continue to expand. Walseal Flanges, Fittings, and Valves have the added advantage of being installed easily even in cramped quarters.

You'll find complete information on Walseal products in the new Walworth Catalog 42 on pages 230 to 242, inclusive.

• • •

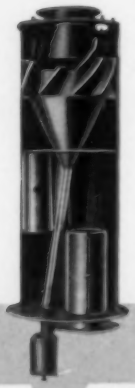
If you want a copy of this up-to-date catalog of Walworth Valves, Fittings, Pipe, and Pipe Wrenches, write for it on your business letterhead. Address: Walworth Company, Dept. 717, 60 East 42nd St., New York, N. Y.

BOSTON WORKS
KEWANEE WORKS

WALWORTH
valves AND fittings

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

Award for silence

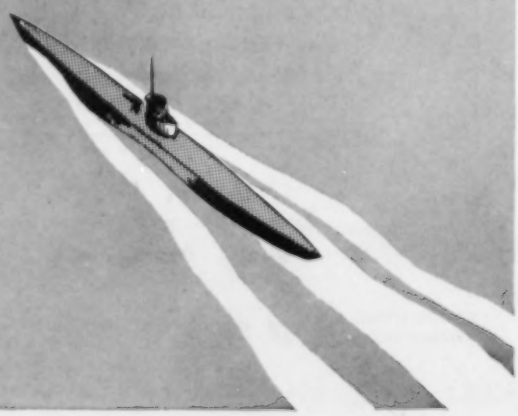


MAXIM

Silence, on the face of it, may seem a strange weapon of war . . . yet every day and every night at sea our ships "come through" because their position is not detected. For many this "positive protection" is due to Maxim Silencers which deaden engine noise to a whisper and trap all tell-tale sparks and embers.

For turning out this vital silencing equipment in ever increasing quantities, Maxim employees have earned the Army-Navy Production Award. Proud of this recognition, they are determined to better the record that earned it for them. The Maxim Silencer Co., 99 Homestead Ave., Hartford, Conn.

Maxim Waste Heat Units combine silencing, spark arresting and the utilization of waste exhaust heat to produce steam or hot water. Write for Bulletin WH-100.



Always ready for action—

TIMKEN BEARING EQUIPPED

Modern maintenance equipment like this Ingersoll-Rand Model KRC-8 Crawl-Air Compressor and Pneumatic Tie Tampers—saves time and cost in keeping railroad track in tip-top condition.

Timken Tapered Roller Bearings are used on the crank shaft of this compressor—as they are in other models of Ingersoll-Rand compressors — to promote maximum smoothness of operation; to prevent crank shaft wear; to protect the crank shaft against radial, thrust and combined loads and hold it in correct and constant alignment. Endurance is increased, compressor life is prolonged and up-keep greatly reduced. The Timken Roller Bearing Company, Canton, Ohio.

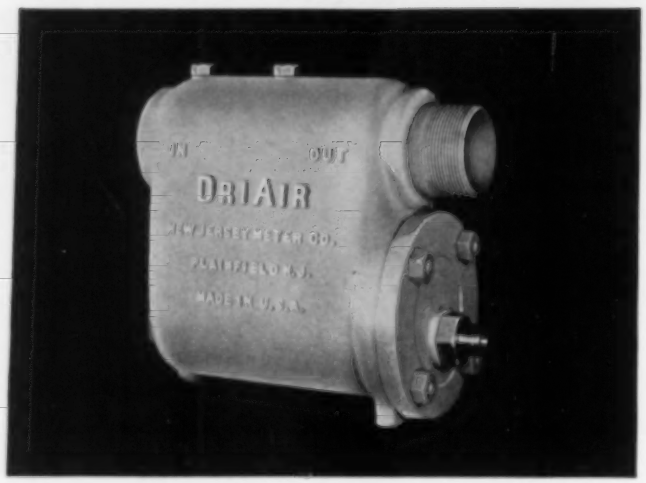
To equipment manufacturers: Don't wait to see what will happen after Victory. Prepare for anything by redesigning now and using Timken Bearings.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

DEPENDABLE PNEUMATIC SERVICE



WHEN EQUIPMENT IS PROTECTED BY

DRIAIR

A COMPLETE SELF-CONTAINED UNIT

DriAir may be installed by suspending it from the piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

● The answer to many problems which arise in various applications of compressed air, DriAir speeds production by separating and automatically ejecting the condensed water and oil from the air. DriAir collects dirt and rust from the air lines and delivers clean dry air to the tools, thus reducing wear and prolonging their life. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent. Copy of Bulletin DA fully describing the operation of DriAir sent on request; write today.

NEW JERSEY METER COMPANY

PLAINFIELD, NEW JERSEY

---

60 years OF SAFETY

. . . since 1883 Genuine CROSBY CLIPS

have been holding wire rope dependably in all kinds of service. Today they are winning new laurels on every battle front on sea and on land.

Correct grip - drop forged steel - hot dip galvanized

AMERICAN HOIST AND DERRICK CO.

Chicago San Francisco New York

SAINT PAUL, MINNESOTA

1883 - 1943

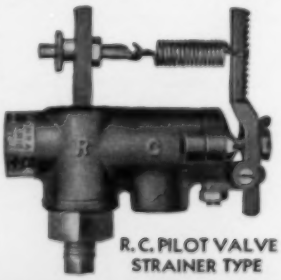
AMERICAN TERRY DERRICK CO.

SOUTH KEARNY, N. J.

FOR SAFETY

R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



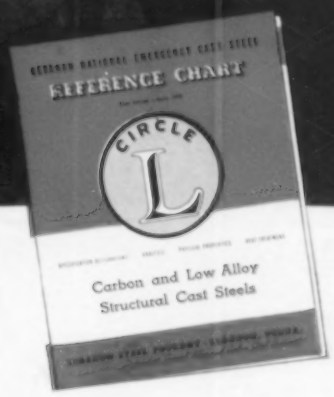
R. C. PILOT VALVE STRAINER TYPE

R. CONRADER CO.

1207 FRENCH STREET - ERIE, PA.

PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

Emergency Steels You Can Trust In ANY Emergency!



CIRCLE Ⓛ National Emergency Cast Steels are "emergency" materials not only in the sense that they save critical alloys—they also possess the quality and integrity to meet the severest tests of operation. All have been approved for production only after measuring up to critical standards based upon the functions each steel is intended to perform.

Lebanon foundry engineers and metallurgists . . . who have had close contact with war production requirements since the beginning . . . will gladly advise you which of these steels fits your requirements. Design, thickness of section, required hardness and shock resistance are always thoroughly studied. The consultation services of these foundry engineers and metallurgists are available upon request to interested organizations.

LEBANON STEEL FOUNDRY, LEBANON, PA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

SEND FOR FREE COPY OF HANDY "MINUTE REFERENCE"

No fumbling...no groping for information! Simply open this *file-size* Lebanon reference chart and the essential facts about Circle Ⓛ National Emergency Cast Steels lie before you—on a single spread. Shows comparative specification designations, nominal analyses, minimum physical properties and heat treatment. The complete chart is available to executives, engineers and metallurgists. Write for your copy.

CARBON STEELS

Lebanon Designation	U. S. Navy Designation	Federal Designation	Emergency ASTM Designation	Similar AISI Type No.	Similar SAE Designation	Similar NE Designation	Nominal Analysis C	Si	Mn	Ni	Cr	Mo
Ⓛ B	49-S-1 (INT) Grade B, C, Cw, D	QQ-S-681b Grade X, 0, 1, 2	EA-A-27-42 Grade B-2 EA-A-215-41 Grade EA-2W EB-W EN-2W EA-A-27-42	1025	1025		.25	.40	.65			
Ⓛ A	49-S-1 (INT) Grade A	QQ-S-681b Grade 3	A-27-39 Grade H	1040	1040		.40	.40	.75	†	†	†
Ⓛ C				1040	1040		.40	.40	.75	†	†	†
Ⓛ D				1040	1040		.40	.40	.75	†	†	†

*NE ALLOY STEELS

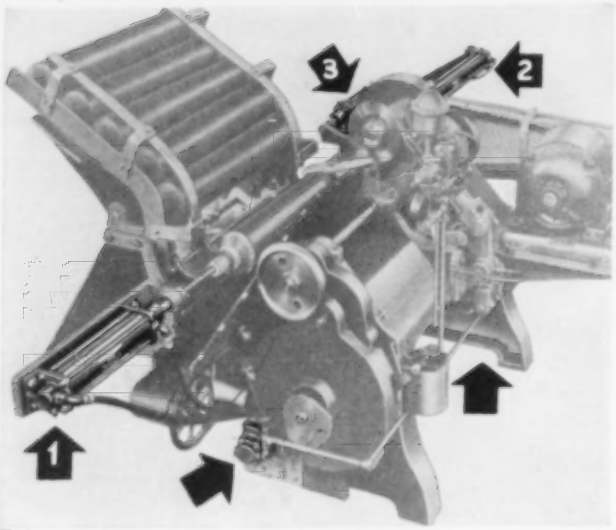
Ⓛ 205 (A)	49-S-1 (INT) Grade F	QQ-S-681b Grade 4A-2	EA-A-148-42 Grade A-2			NE8630	.30	.40	.80	.60	.60	.20
Ⓛ 205 (B)		Grade 4C-2	Grade C-4			NE8630	.30	.40	.80	.60	.60	.20
Ⓛ 205 (C)		Grade 4C-3	Grade C-2			NE8630	.30	.40	.80	.60	.60	.20
Ⓛ 205 (D)		Grade 4C-4	Grade C-3			NE8630	.30	.40	.80	.60	.60	.20

† Residual alloys contained.
* Supplied with approval of W.P.B.

NOTE: Other Ⓛ standard grades of alloy steel castings available with proper priority and W.P.B. approval.

LEBANON *Stainless and Special Alloy* STEEL CASTINGS

COMPLETELY AUTOMATIC



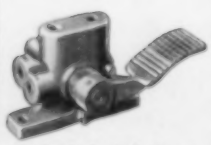
Thanks to NOPAK Air Valves and Cylinders

Arrows above indicate location of NOPAK Air Cylinders and Operating Valves.

V & O Cartridge Case Trimming Machines — built by The V & O Press Co., Hudson, N. Y. — are a fine example of the application of air power to precision machine movements. Three Model "A" Air Cylinders are used on each machine: — One for gauging and trimming, the second for ejecting the trimmed cases, and the third for stripping scrap metal from the trimming chuck.

3 Model "A" Air Cylinders, in varying strokes and sizes, are used on each V & O Trimmer.

Each cylinder is controlled by a Model "R" NOPAK Foot-Type Valve actuated by cams accurately synchronized to maintain production at 18 cases per minute.



3 Model "R" Foot Valves, adapted to cam operation, actuate each cylinder.

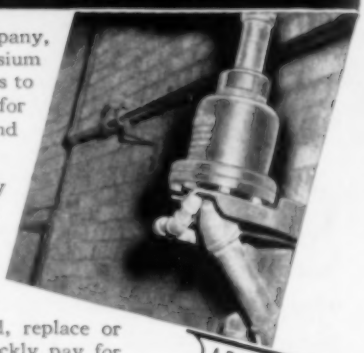
Inquiries are invited from machine designers, tool engineers and production managers who may be able to use similar applications of air or fluid power to master specific problems of design or production.

GALLAND-HENNING MFG. CO.
2759 SOUTH 31st STREET • MILWAUKEE 7, WISCONSIN

NOPAK *Representatives in Principal Cities*
VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

A 4065-½

Leading Magnesium Plant Uses Aridifiers to Stop Dirty Air Troubles



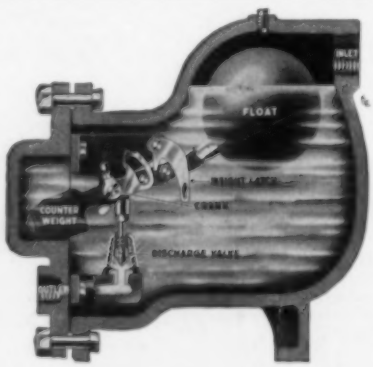
Howard Foundry Company, world's largest magnesium foundry, uses Aridifiers to provide clean, dry air for molding, grinding and finishing operations.

Aridifiers effectively remove moisture, dirt and fine scale from compressed air and gas lines by *centrifugal force*. Nothing to clean, become clogged, replace or require attention. Quickly pay for themselves in lowered maintenance costs. Send for bulletin.

LOGAN ENGINEERING CO.
4911 Lawrence Avenue
Chicago, Ill.

Engineering Representatives in Principal Cities

The ARIDIFIER
Dries and Cleans Compressed Air



NICHOLSON "JR"

A Compressed Air Trap Designed for Dependable and Automatic Drainage of Water and Oil from Air Tanks, Receivers, Aftercoolers, Etc.

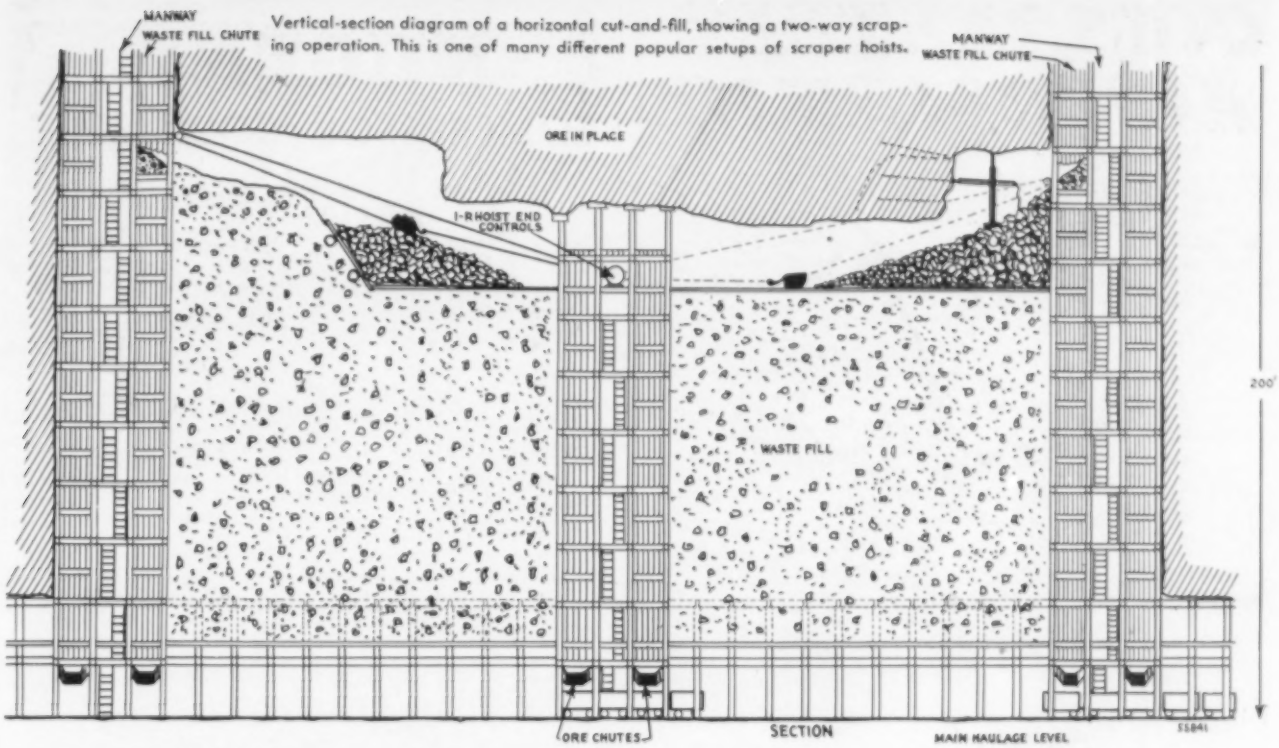
Specially designed and constructed to provide long, trouble-free service under continuous operation. Large capacity . . . for pressures up to 125 lbs. . . . intermittent discharge . . . welded stainless steel float . . . water sealed discharge valve . . . made in one pattern size only with either ½", ¾" or 1" inlet and ½" outlet. Bulletin No. 341.

W. H. NICHOLSON & CO., 180 OREGON ST., WILKES-BARRE, PA.

NICHOLSON Traps

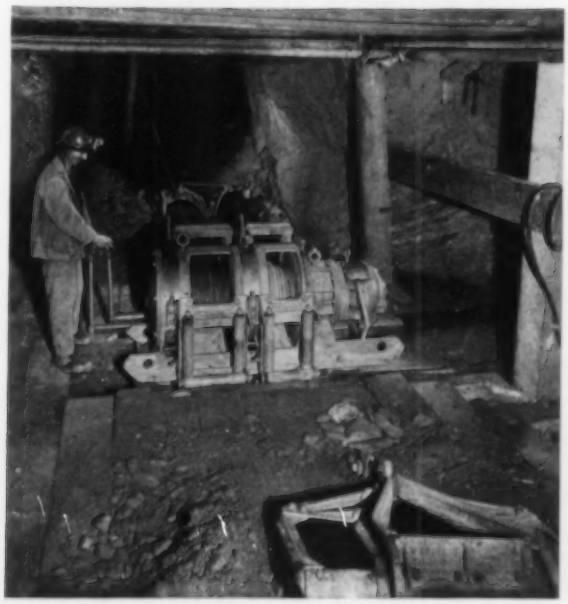
THERMOSTATIC ▼ PISTON AND WEIGHT-OPERATED STEAM
GASOLINE AND COMPRESSED AIR TRAPS ▼ ▼ ▼

CONTROL VALVES ▼ FLOATS ▼ MANDRELS ▼ STEAM AND AIR SEPARATORS



Vertical-section diagram of a horizontal cut-and-fill, showing a two-way scraping operation. This is one of many different popular setups of scraper hoists.

SCRAPERS MULTIPLY MANPOWER



A 50-hp Ingersoll-Rand Electric "Tugger" Hoist equipped with end controls for two-way scraping on a heavy-tonnage transfer installation.

To meet unprecedented tonnage demands, many mines are adding slusher-hoist equipment—because scraper mucking means:

1. **Relief of labor shortage**—New men can quickly learn to use scrapers and can thereby release older heads to perform the more exacting operations.
2. **Less development work**—The use of scrapers permits an ore body to be developed and put into production with fewer men.
3. **More tonnage mined**—Scraping speeds up mining. Frequently, loading and tramming are combined in one operation.
4. **Conservation of critical supplies**—Areas are worked faster. This results in direct savings of time, labor, timber, rails, and other supplies.
5. **Greater safety**—Stoping hazards are reduced to a minimum. The mucker is a safe distance from many of the sources of possible danger.

Realizing the increased interest in labor-saving methods under wartime conditions, we have obtained a supply of booklet TP-1603, "Multiplying Manpower with Scrapers." This is a condensation of a paper presented before the February meeting of A.I.M.E. The booklet describes and illustrates the application of slusher hoists to various methods of mining, such as timbered cut-and-fill stoping, untimbered cut-and-fill stoping, underhand stoping, block caving, top-slicing, sub-level caving, shrinkage, square set and stull timbered stoping, etc.

A study of this booklet will show how the scraper hoist can multiply manpower and help maintain high tonnages. Send today for copies for your organization.

Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.

16-321

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

SAVE!—

your KOH-I-NOORS *are good to the end*

Today, with forced economies facing us at every turn, it is more than ever necessary that you choose your pencil with infinite care.

W.P.B. Limitation Order L-227, definitely restricts wood cased pencil production in 1943 and while there is no alarming shortage of pencils at the moment, still it is imperative that pencil users get the greatest value from their pencil expenditures.

KOH-I-NOOR DRAWING PENCILS bring you every pencil quality—smoothness, density of lead, long wear and accurate grading throughout the entire length of lead. Use KOH-I-NOOR to the end.

Send for Booklet No. 19

KOH-I-NOOR
PENCIL COMPANY INC.
373 FOURTH AVENUE · NEW YORK

NUGENT

COMPRESSOR EQUIPMENT

- - - helps Compressors to KEEP OPERATING EFFICIENTLY.

NUGENT Flared Tube Union Fittings will help keep compressor equipment operating **full time**, with maximum efficiency. These fittings are constructed to withstand vibrations at high pressure without pressure leakage. The flared tube makes its joint on the end of the fittings hence, the tubing must only be sprung over the seat on the end of the fitting, which is 3/32" on small sizes and 1/4" on larger sizes. Nugent Fittings are made in all the styles shown in sizes 1/8" to 3/4" O.D. pipe sizes.

WM. W. NUGENT & CO., INC.
422 N. Hermitage Ave., Chicago, Ill. Est. 1897

HEADQUARTERS for
COMPRESSION
TUBE FITTINGS (Pipe Size O. D.)

DON'T BE PENNY-WISE AND TON-FOOLISH ABOUT SCRAP!

Run Your Scrap Program According to This Rule:

If it hasn't been used for three months, and if some one can't prove that it's going to be used in the next three—sell it—or scrap it! Scrap and used equipment dealers pay well for useable machinery and materials.

It's easy to salve your salvage conscience by turning in the junk you'd been meaning to get rid of anyway. *But this is not enough!*

To end the shortage of heavy steel scrap you've got to dig deeper. Mills are going to need about 26,000,000 tons of purchased scrap this year! To make sure that the men we've sent to war will have the weapons they need, you've got to get rid of every piece of idle "slacker" metal in your plant. Sell it—either as scrap or as second hand equipment.

Can't Get Enough Copper

Shortest of all is copper, and officials say this critical shortage will continue for the duration. Copper refineries are not operating at full capacity . . . when they should be running wide open! Who knows how long that one scarcity may delay the final big push!

Deduct Value From Your Income Tax

Remember . . . if the item you scrap still appears on your books, it can be deducted. Otherwise it cannot. This is a matter for your accountant or attorney to decide. Even if not deductible, don't hoard it. For used machinery especially there's a big and continuing demand. *Somebody needs it—badly!*

BUSINESS PRESS INDUSTRIAL SCRAP COMMITTEE
Room 1310, 50 Rockefeller Plaza, N. Y. C.

If you have done a successful salvage job at your plant, send details and pictures to this magazine. Send for booklet—"Primer of Industrial Scrap."

NEW TOTALLY ENCLOSED TRI-CLAD MOTOR

FULLY ARMORED AGAINST THE ENTRY OF DESTRUCTIVE MATERIALS—RESISTANT TO CORROSION AND EXTERNAL DAMAGE

On this new member of the Tri-Clad motor family, end shields and frame are solid cast iron, smoothly contoured and tightly fitted. Ball bearings are protected by a rotating-labyrinth bearing seal—against damaging dusts or liquids. The leads are sealed in compound in a cast-iron pocket in the frame. Inside, the motor has all the extra-protection features of Tri-Clad open motors, such as Formex* wire.

An outstanding feature of these new motors is that their mounting dimensions are interchangeable with those of open motors of like rating.

For complete information on the totally enclosed Tri-Clad, see your G-E representative, or write to General Electric Co., Schenectady, N. Y.

*Reg. U.S. Pat. Office

FRAME SIZES

Hp	Rpm	Poly-phase	Single-phase
1/2	900	204	
3/4	1200	203	204
3/4	900	224	
1	1800	203	203
1	1200	204	
1	900	225	
1 1/2	3600	203	203
1 1/2	1800	204	204
1 1/2	1200	224	
2	3600	204	204
2	1800	224	

FOR "CRUEL" SERVICE CONDITIONS LIKE THESE

(Meeting requirements of WPB Motor Conservation Order L-221)

DESTRUCTIVE DUSTS*
Where rock dust, metal filings, powdered chemicals, or other finely divided materials are present in destructive quantities.

CORROSIVE FUMES*
Where motors are exposed to corrosive acids and alkalies in liquid or vapor form, such as on mixers in chemical pilot plants.

GUMMY, VISCOUS MATERIALS
In working with paints, oils, syrups, and other materials which might "gum up" the interior of an open motor.

SUPERSATURATED ATMOSPHERES
Where motors must operate without fail in areas filled with steam, water vapor, oil droplets. Also out of doors in humid, stormy climates.

* In addition to this *standard* totally enclosed Tri-Clad motor, G. E. can furnish *explosion-proof* types, tested and listed by Underwriters' Laboratories, Inc., for (1) hazardous dusts, such as magnesium dust, coal dust, grain dust, (2) hazardous fumes, such as gasoline.

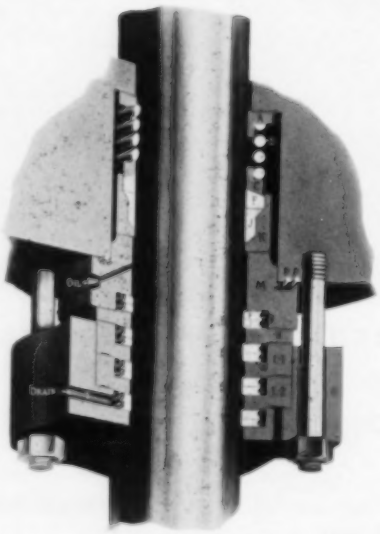
GENERAL ELECTRIC

EXPERIENCE SAYS COOK'S PACKINGS *for Liberty Ships*

They made good before — they'll do it again!

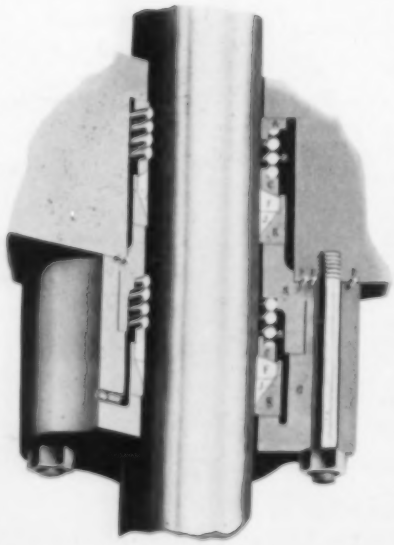
Just as COOK'S Metallic Packings on Compressors are assisting the war effort in the manufacture of aviation gas, synthetic ammonia, synthetic rubber and other chemical products, so also are they playing a great part on the high seas where they are going into over 50% of the Liberty Ship engines along with many hundreds of other marine engines for so called "special" ships.

C. LEE COOK MFG. CO.
INCORPORATED
LOUISVILLE, KY.



COOK'S PACKING
TYPE 201-C
on the H.P. Piston Rods

SEALING PRESSURES SINCE 1888



COOK'S PACKING
TYPE 202
on the M. and L. P. Rods
and all Valve Stems

SERVICE OFFICES

With a nation-wide service organization, operating engineers of all types of equipment fitted with COOK'S Packings should feel free to call on COOK'S field men when adjustment or service is required. Following is a list of offices:

Baltimore	Los Angeles	Portland, Ore.
Boston	Mobile	San Francisco
Chicago	Montreal	Seattle
Cleveland	New Orleans	Tulsa
	New York	

COOK'S METALLIC PACKINGS

G P M — *gallons per minute*

From an engineering abbreviation, G P M has grown to major significance in a world at war. For G P M implies liquids put to work, largely by *centrifugal pumps*, so that we can have

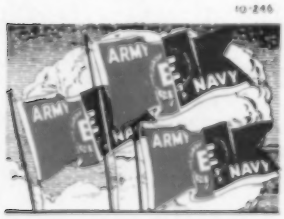
More sea power . . . more ammunition . . . more metals and coal . . . more oil and gasoline . . . more synthetic rubber . . . more machine tools . . . more chemicals . . . more foods . . . more power . . . more of those things needed to attain victory.

More centrifugal pumps built to resist corrosion, to avoid severe shock, to meet new demands in pressures and temperatures, to solve countless problems in numberless complex and simple applications.

The Cameron Division of Ingersoll-Rand is working to capacity, developing and building such pumps for this war. It has built them for all wars since 1860. Ingersoll-Rand Company, 11 Broadway, New York City.

All plants of Ingersoll-Rand Company are flying the Army-Navy "E" awarded "for high achievement in the production of war materials."

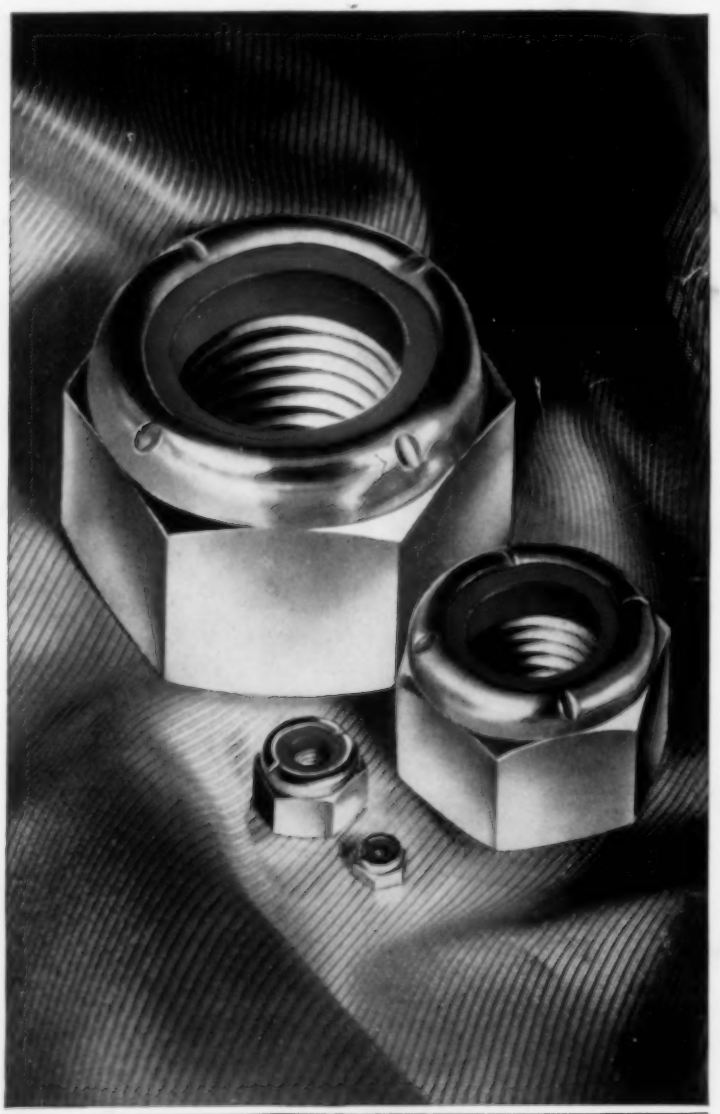
10-246



Ingersoll-Rand

CENTRIFUGAL PUMPS · CONDENSERS · OIL AND GAS ENGINES
COMPRESSORS · TURBO BLOWERS · ROCK DRILLS · AIR TOOLS

They're the NUTS for tough fastening jobs



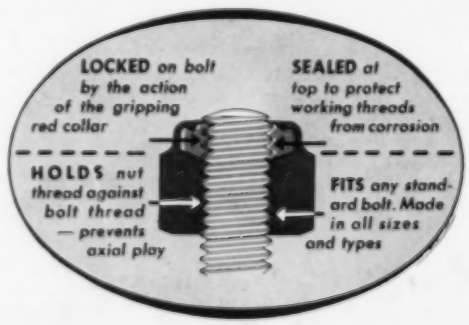
There are more Elastic Stop Nuts in America's planes, tanks, guns, naval vessels and production equipment than all other lock nuts *combined.*

All because these nuts stay put.

The reason is the red elastic locking ring in the top. This grips the bolt and holds the threads in pressure contact. And chance of wobbling and axial play is eliminated.

Looking ahead, we see better products and manufacturing equipment — we see time and money saved in maintenance and replacements — all because of these nuts that have proved they hold fast even under grueling vibration — that are easy to put on and take off yet lock automatically anywhere on the bolt.

Our engineers, experienced in solving fastening problems both in peace and war, are ready to share their knowledge with you. They will gladly work with you and recommend the correct Elastic Stop Nut to meet your need.


LOCKED on bolt by the action of the gripping red collar
SEALED at top to protect working threads from corrosion
HOLDS nut thread against bolt thread — prevents axial play
FITS any standard bolt. Made in all sizes and types

ELASTIC STOP NUTS

Lock fast to make things last

ESNA
TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA
UNION, NEW JERSEY AND LINCOLN, NEBRASKA